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ABSTRACT

This curriculum resource guide, one of seven developed by the State of Illinois to present information on new and emerging curricula existing in the nation, can be used as a basis for local educators to determine the resources needed to offer solar technology curricula and to initiate curriculum development at the local level. Chapters 1 and 2 contain an introduction and procedures for using the guide. Chapter 3 describes the job duties and typical employers of solar energy technicians. In chapter 4 alternative curriculum approaches are presented--an associate degree program, certificate program, and heating, refrigeration, and air conditioning option. Chapter 5 discusses these resources required to implement the program: curriculum advisory committee, facilities and equipment, and instructor qualifications. The final chapter (chapter 6) contains forty-six abstracts of curriculum and instructional materials; information provided includes title, author(s), availability, and price. Appendixes include lists of schools offering coursework in solar energy technology, related agencies/organizations and journals/periodicals/news publications, task listings and job competencies, and equipment lists. (A report on the project that identified the seven new and emerging occupations is available as CE 025 423. See Note for other curriculum resource guides in ERIC.) (YLB)

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SOLAR ENERGY TECHNOLOGY: A CURRICULUM PLANNING AND RESOURCE GUIDE

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PREFACE

In 1978 CONSERVA, Inc. was awarded a contract by the Illinois Department of Adult, Vocational, and Technical Education (DAVTE) to identify new and emerging occupations within the State and to determine the types, levels, and distribution of new vocational education curricula which are needed to meet the employment demands for skilled workers in those occupations. To accomplish the objectives of the project, CONSERVA staff undertook a search for potential new occupations through a review of similar national research efforts, recently enacted Illinois legislation, and technical and trade journals. Telephone contacts to identify new and emerging occupations were made with over 450 individuals nationwide, representing industries, educational institutions, professional and trade associations, government agencies, labor unions, service organizations, and private employers.

Through these cumulative efforts, seven occupations were identified which met pre-determined criteria defining new and emerging occupations, i.e., 1) the occupation has come into existence within the past decade; 2) the occupation is skilled or technical in nature, requiring at least six months of vocational education preparation but less than a four-year college program; 3) there are no or limited vocational education programs within Illinois which are preparing students to enter the occupation; and 4) information is currently available which reflects an anticipated shortage of workers within the State over the next five years. The seven identified new and emerging occupations are:

- Biomedical equipment technician
- Industrial hygiene technician
- Podiatric assistant
- Therapeutic recreation technician
- Swine confinement facility assistant manager
- Solar energy technician
- Halfway house manager

In order to hasten the inauguration of curricula for these new and emerging occupational areas, the Illinois Department of Adult, Vocational and Technical Education (DAVTE) awarded a second contract to CONSERVA. The purpose of that project was to locate new and emerging curricula that are currently in existence in the nation, to obtain available curriculum documentation for each of the seven occupational areas and to incorporate that information into seven curriculum resource guides. This volume represents one of the products of that effort, a curriculum resource guide which can be used as a basis for initiating a curriculum for preparing Solar Energy Technicians.

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I. INTRODUCTION

There has been a surge of interest and activity in the solar energy field within the last several years. This trend has been precipitated by the rapidly rising costs of non-renewable energy sources, such as petroleum and natural gas, the realization that these finite energy supplies are being depleted and the desire for national energy independence. In the nation's endeavor to achieve an ecological balance and to conserve our natural resources, solar energy has emerged as an attractive energy alternative. In light of new developments in the solar field and the high cost of oil, it has become more economically feasible to rely on solar power for a larger portion of our energy needs. Between 1974 and 1977 the production of medium temperature solar collectors increased 15-fold (U.S. Department of Energy, *Annual Report to Congress*, 1977), and the number of solar equipment distributors grew from four to over 90 within Illinois. The increasing utilization of solar energy systems in residential and commercial buildings for space heating and cooling and water heating has given rise to the occupation of solar energy technician and produced an urgent need for training in solar-related skills.

It has been estimated that the five-year demand for solar technicians in Illinois is 431 statewide, with over half of these positions concentrated in the Chicago area (Spetz, et. al., 1978). This estimate is based on the 1977 Department of Energy projections that by the year 1990, seven million homes in the United States will have solar systems. In the wake of President Carter's energy message (July 15, 1979), prospects for research and development in solar energy appear even more promising. The President expressed his support for a national goal that by the year 2000, 20 percent of the energy consumption in the United States be supplied by solar energy. In view of these estimates and projections, the number of vocational institutions in Illinois currently offering solar technology programs is not adequate to meet the anticipated demand.

This curriculum planning and resource guide was prepared to serve as a basis for local educators and to determine the resources needed to offer solar technology curricula and to initiate curriculum development at the local level. The difficulties and expense of developing curricula for a relatively new occupation such as solar technology are well documented (Meleen, et al., 1976; Nelson, 1978; Spetz, et al., 1978; and Forgione & Kopp, 1979). This guide is intended to facilitate solar technology curriculum development in Illinois by taking full advantage of related curriculum development efforts of institutions across the nation.

Essentially, the curriculum planning and resource guide is a synthesis of curriculum materials currently being used to offer training in solar energy technology. It consists of a description of job duties and competencies, suggested curriculum options, program resource requirements, abstracts of curricular materials, and appendices listing further sources of information. Information presented in the guide was obtained from existing curricula in solar energy technology (see Appendix A), which were identified through extensive contacts with State vocational education agencies, professional and trade associations and directories, and local institutions offering solar technology curricula. In most instances, representatives of solar technology curricular graciously provided CONSERVA with documentation of available curriculum materials and offered assistance in identifying instructional materials, resource requirements, and other useful information. Contacts made with educational publishers, solar energy equipment manufacturers and producers of audio-visual instructional materials served to identify and procure textbooks and other learning materials available for providing instruction in solar energy technology.

Suggested procedures for using the curriculum planning and resource guide are presented in the next chapter, which describes a five-step curriculum development process keyed to the contents of this guide. This is followed by chapters describing job duties of solar energy technicians, alternative curriculum approaches, and program resource requirements. The final chapter presents abstracts of available curriculum and instructional resources.

II. PROCEDURES FOR USE

Presented in this chapter are procedures for using this guide as a resource in the planning, organization and development of a curriculum in solar energy technology. The approach advocates the reliance on existing solar technology curricula which have been developed by other institutions. Though it is seldom practical or feasible for an institution to adopt an existing curriculum in its entirety, the work of others does offer a solid foundation upon which to base planning and development activities. The steps outlined below illustrate how the materials presented and referenced in this guide can be utilized in initiating a curriculum for solar energy technology, an occupation which has been determined new and emerging in Illinois, yet one for which there are established curricula in other parts of the country.

The curriculum development process is summarized in Table 1, accompanied by a rationale for each of the procedural steps and references to relevant sections of the resource guide. The procedures elaborated upon below assume experience in curriculum development on the part of the reader. Steps which are well-known to those with such experience are briefly outlined and tied in to relevant information presented in this guide. In those instances where traditional curriculum development procedures are not appropriate due to the newness of the occupation, further elaboration is provided.

Table 1.
Curriculum Planning and Development for New and Emerging Occupations

Step	Purpose	Reference
1. Determine area or regional employment opportunities and extent of student interest	To justify offering the program	Figure 1 Chapter III
2. Establish curriculum advisory committee	To obtain advice on the structure and content of the curriculum and the methodology to be utilized in instruction	Chapter V Appendices B, C
3. Verify, modify, and refine job competencies and/or duties	To align general duties with specific local employment requirements	Chapter III Appendix D
4. Assess resource requirements	To determine institutional capability to offer the program	Chapter V Appendix E
5. Develop curriculum	To align resources with job competencies and student interests and qualifications	Chapters IV, V, VI Appendix F

Step 1. Determine Area or Regional Employment Opportunities and Student Interest.

The first step in planning a curriculum for solar energy technology is to determine the demand, in terms of employment opportunities and student interest, for offering training in the occupational area. Five-year projections of regional demand for solar technicians have been estimated using data on the distribution of plumbers and pipefitters and the predicted growth rate of solar homes (Spetz, et al., 1978). These projections, which are portrayed in Figure 1, can serve as a preliminary estimate of employment demand. However, since the estimates are based on secondary sources of regional employment demand,they are subject to local fluctuations. Thus, if the regional estimates indicate a potential need for a program in solar technology, a more in-depth investigation of the demand should be undertaken. This will first involve conferring with other post secondary and/or proprietary schools in the region to determine whether any of those institutions are planning to respond to the need by developing similar curricula. Findings from such conferences could result in the need for joint developmental efforts or a determination that only one operating curiculum is necessary to meet the regional demand. In the latter case a joint decision between the institutions and the appropriate State agency as to the most qualified and/or cost-efficient institutions(s) to offer training should be sought.

The next step is to refine the preliminary demand estimates through a survey of the potential employment community. Job duties and typical employers of solar technicians are listed in Chapter III of this report. That information may be used as a basis for the development of survey instrumentation and selection of a sample of employers. It will be necessary to include a solar technician job description in the instrumentation. This will ensure that employers are responding to similar positions even if the position is not referred to as a solar energy technician. Additionally, employers should be requested to list any discrepancies in the job description as compared to the duties of their solar technician. Contacts made with employers during the survey process should further serve to reveal additional places of employment or solar technicians, to identify potential curriculum advisory committee members and/or participants in a cooperative vocational education program and to stimulate community interest.

The other component of demand which is necessary to estimate prior to curriculum development is student interest in, and qualifications for, the solar energy technology curriculum. This is particularly important for ensuring sufficient enrollment when large expenditures, particularly for equipment purchases and instructional costs, are anticipated. The information on job duties (Chapter III) and typical curriculum and course requirements (Chapter IV) can help to determine potential student interest in enrolling

in a solar technology curriculum. Summaries of that information can be provided to career information or guidance centers and secondary school guidance counselors in the service area to obtain estimates of potential student interest.

When the necessary information on students' interests is not directly available from the career information centers or guidance counselors, it may be desirable to conduct a survey of potential students. The sample could include students enrolled at the institutions, secondary students enrolled in both public and private institutions, and selected out of school populations such as persons employed in the related field of heating, air conditioning and refrigeration. Again, the information on job duties and curriculum and course requirements contained in Chapters III and IV can be summarized in the survey instrument. The results of the survey will not only provide information on student demand but also indicate the types of students the curriculum is most likely to attract—information that later will be useful in designing a curriculum. If the decision is made to offer the curriculum, these potential solar technology students should be made aware of its availability.

Step 2. Establish Curriculum Advisory Committee

The second stage of the development process, provided that sufficient demand exists for the curriculum, is to establish a curriculum advisory committee. Since the committee will be heavily involved in subsequent steps in the curriculum development process, it is imperative that in the selection of members adequate consideration be given to individuals' qualifications in light of the responsibilities of the committee. Potential members of a solar technology curriculum advisory committee are presented in Chapter V. Additionally, the institution may wish to include outside consultants on the advisory committee if insufficient local expertise exists. Since solar energy technology is a relatively new field, it may be essential to solicit external, up-to-date information. This may be obtained from relevant agencies and organizations, in addition to consultants. Lists of potential consultants for developing a solar energy technology curriculum and relevant groups are presented in Appendices B and C, respectively.

At the first meeting of the advisory committee, it is suggested that procedures for the operation of the committee, extent of authority, principal objectives and time schedules be established. Subsequent responsibilities of the committee will be to ensure that the curriculum is consistent with employer requirements and to facilitate placement of students.

Step 3. Verify, Modify and Refine Occupational Competencies and/or Duties

The derivation of job competencies can be a time-consuming and difficult task, particularly for new and emerging occupations. An alternative is to verify and refine existing competencies and/or task listings. Various lists of occupational competencies and tasks of the solar technician, which supplement job duties described in Chapter III, are presented in Appendix D. These should be reviewed and refined to reflect unique and general employment requirements of the institution's service area. Input from the curriculum advisory committee and/or employers surveyed in Step 1 will facilitate the accomplishment of this process.

Employer input may be obtained concurrently with the survey conducted in Step 1 by appending a list of tasks or competencies to the survey questionnaire. Employers are requested to rate tasks, manipulative and communication skills, and technical knowledges as to their relevance to the occupation. For example, a five-point rating scale could be applied to a list of skills.[1]

5 - The skill is essential
4 - The skill is very important
3 - The skill is desirable
2 - The skill is not important
1 - The skill is not applicable

A similar scale could be applied to the rating of tasks and technical knowledges. Employers should also be given the opportunity to add to or modify the presented skills, tasks, and technical knowledges. Based on the employer ratings and similar input from curriculum advisory committee members, job competencies can be refined to reflect the needs of the service area. These refined competencies should then be used in defining segments of a solar technology curriculum.

Step 4. Assess Resource Requirements

In order to determine the capability of an educational institution to offer the curiculum, it is necessary to assess the capabilities of the instructional staff, facilities and equipment available to provide students with the needed manipulative skills, technical knowledge and communication skills. The available resources will have a definite impact on the structure of the curriculum developed in the next step. For example, if equipment necessary for teaching laboratory skills is not available, a cooperative program may be considered.

The types of equipment, facilities and instructors necessary for implementing a solar energy technology curriculum are presented in Chapter V. With the assistance of the curriculum advisory committee, suggested resources should be evaluated in light of the refinements in job competencies made in Step 3. Additions or changes to resource requirements may be necessary to align them with unique area or regional employment requirements. The resources of the institution should then be assessed as to whether they are adequate to meet the requirements of a solar energy curriculum. Where resources are lacking, outside assistance could be solicited; e.g., equipment contributions from manufacturing firms, supplementary guest lectures, equipment demonstrations by suppliers or field trips. Cooperative arrangements with solar technician employers, consisting of on-site learning opportunities for students, could also serve to lessen the burdens of expenditures for equipment and instructional resources.

Step. 5. Develop Curriculum

At this point, it will be appropriate to determine the curriculum objectives and course progression, instructional materials, and methods and modes of instruction to be used in teaching students the necessary competencies to function as solar energy technicians. Curriculum advisory committee input is most important during this phase of the curriculum planning process. Suggested solar technology curriculum options, which are based on curricula currently in use in institutions across the nation, are presented in Chapter IV. Dependent on institutional resources, area or regional competency requirements, and anticipated student interests and

[1] From Johnson County (Kansas) Community College, Office of Institutional Research. "Employer Manpower Needs and Job Entry Requirements for Biomedical Equipment Technician."

Figure 1.
1978-1983 Regional Employment Requirements for Solar Energy Technician (Statewide Total - 431)

qualifications, one or a combination of the curriculum options may be selected. Curriculum and coursework content may then be modified or expanded to address curriculum objectives and unique service area and institutional requirements. Other curriculum guides and materials obtained from existing programs are abstracted in Chapter VI. These guides and materials may be of further use in determining the appropriate curriculum and will be available for local review from the East Central Curriculum Coordination Center in Springfield.

Once the curriculum has been outlined and course objectives established, appropriate instructional materials for achieving the objectives will need to be identified. This process can be facilitated by reviewing the abstracts of instructional materials presented in Chapter VI. The abstracts should be reviewed with the following considerations in mind:

- Relationship of the material to course objectives
- Consistency of the material with mode and methods of instruction
- Compatability of the material with students' anticipated levels of achievement
- Effectiveness of the material in presenting information
- Cost-effectiveness of the material

Selection of materials for instruction should of course be preceded by a critical review of the actual documents, audio-visual, materials, etc.; however, alternatives may be narrowed down by examining abstracts contained in Chapter VI. A majority of the materials abstracted have been procured and will be made available by DAVTE to local educators for further review, preview and assessment of learning possibilities.

The steps outlined in the foregoing discussion represent an approach to curriculum development that relies heavily on the developmental efforts of others. However, it is not suggested that an existing curriculum be adopted in whole without giving due consideration to the transferability of such components as regional employer requirements, student needs, and resource and institutional requirements. The value of a curriculum advisory committee in addressing these considerations has been stressed throughout the curriculum development process. If the recommended steps are taken in the planning and development of the curriculum, the guide may serve to eliminate duplication of effort and as such can represent a cost-effective approach to curriculum development.

III. JOB DESCRIPTION

This chapter describes the job duties and typical employers of solar energy technicians. The information is intended for use during two steps of the curriculum planning process. First, it can serve as a guide when contacting employers and students to determine employment opportunities for solar technicians and student interest in enrolling in a solar energy technology curriculum. Secondly, the general information on job duties and the specific competencies presented in Appendix D can be reviewed, modified and refined by employers and advisory committee members so as to ensure that the curriculum will be responsive to the specific solar technology occupational skills needed in the service area.

Solar energy technicians perform functions that can be classified under four major areas: sales, design, installation and maintenance. Dependent upon the employment setting, the job duties may be specific to one of these four areas, or they may include elements of each. The sales aspect of the technician's job functions requires a thorough technical knowledge of the specific applications of solar technology and the various types of solar systems. The solar salesperson describes different systems in terms of their expected performance, modes of operation, required maintenance and how they will be integrated with conventional systems. In addition, he/she recommends the optimum system for each application and then estimates the cost of that system.

In the design aspect of solar technology, the technician produces detailed written specifications of a solar system in collaboration with the project architect and/or mechanical engineer. The technician is responsible for determining the optimum system size and calculating the anticipated performance of the system in a given geographic location. Typically, this requires reasonable familiarity with computer programs such as FCHART and SOLCOST. If not involved directly in the installation and maintenance of the system, the technician provides technical assistance during those phases by producing detailed descriptions, drawings, charts and thermodynamic data.

The solar system installer is responsible for translating the designer's blueprints into a properly installed system. This entails supervising or assisting in a number of technical tasks such as constructing or assembling system components, mounting collectors, connecting pipes and ducts; installing the various hardware of the system, and, to a limited extent, connecting electrical wiring in the system controls. The solar technician supervising the installation must ensure conformance to local building codes and ordinances and to the original design specifications. The technician is responsible for integrating the solar system with the existing conventional systems for heating and cooling.

The job duties associated with the service and maintenance aspects of solar energy technology overlap considerably with those required during the installation. The service technician must have thorough technical knowledge of all solar system operations in order to perform the necessary maintenance and repair functions. The technician makes periodic performance checks to ensure that the system is operating at acceptable efficiency levels. At this stage the technician takes the necessary measures to troubleshoot potentially problematic situations. If a breakdown occurs, the technician is responsible for locating the source of trouble and adjusting or repairing the faulty apparatus. This requires skill in repairing the various mechanical devices in the system, such as motors, pumps and valves, and the application of heat transfer principles in making calculations for comparing actual heat flows to those specified in the design plan. Additionally, the service technician is responsible for system start-up

Very often solar energy technicians are hired into employment settings not strictly related to solar energy system work. For example, technicians are employed by heating and air conditioning contractors, plumbing contractors and construction firms. In such cases when technicians are not involved in solar activities, they perform an even broader range of tasks than those described above. Dependent upon the employment setting, solar technicians may be required to demonstrate skills in sheet metal fabrication; installing and servicing conventional heating, air conditioning and refrigeration systems; pipe fitting and assembling; or installing and repairing fixtures of water and drainage systems.

More detailed descriptions of the manipulative skills and technical knowledges necessary for performing the job functions of a solar technician are presented in Appendix D. Included in this appendix are (1) a list of tasks and skills associated with six identified job functions developed by the Solar Energy Task Force and the Solar Energy Research Institute, in cooperation with the Department of Energy; (2) a list of task requirements for two jobs identified as solar mechanic and solar technician, developed by William D. Hunt of Southwest Energy Management, Inc.; (3) a list of standards (job functions) and needs for solar system designers and installers developed by Karaki, Ward and Winn; and (4) the tabulation of a task inventory developed by the Texas State Technical Institute to assess needed skill requirements in the service area of the institution.

IV. CURRICULUM APPROACHES

This chapter provides information on the structure of solar energy technology curricula and the content of specific courses designed to provide students with the various skills and technical knowledge necessary for employment as solar energy technicians. The curriculum structure and content reflect alternative approaches for the preparation of solar technicians. Each alternative is presented for consideration in light of institutional resources and service area needs; they are intended to serve as a framework which can guide in developing solar energy technology curricula within Illinois.

The training of solar energy technicians has been approached in a number of ways which have proven successful in various situations. The length and content of alternative curricula vary, dependent upon student interests and need as well as regional labor market characteristics and employer needs. Currently, three basic approaches are in operation nationwide:

- Associate degree program
- Certificate program
- Heating, Air Conditioning and Refrigeration curriculum: Solar Energy Technology Option

Associate degree programs typically require two years of coursework to complete. In addition to courses specific to solar energy technology, classroom and laboratory study are provided in heating and air conditioning, sheet metal fabrication, drafting, physics, electricity and general education courses required for graduation. Practicum experience or cooperative work experience with a solar firm or related business is often available for students interested in applying the theoretical principles learned in the classroom; however, it is not typically required. A design project generally serves as a source for the practical application of solar theory.

Certificate programs consist of less coursework than the associate degree programs and generally can be completed in one year. The curriculum may provide only technical portions of the two-year program or may prepare students to enter employment at a lower level of proficiency by providing a broad introduction to the field

An option within an associate degree heating, air conditioning and refrigeration curriculum provides technicians in that field with some specialization in solar technology. Students may choose to specialize during their second year of education by selecting solar technology courses as part of their programs of study. Alternatively, the specialization may require an extra quarter or semester of solar technology coursework or internship by students who have completed a regular heating, air conditioning and refrigeration curriculum

The following sections of this chapter describe in greater detail the three approaches outlined above. Suggested curricula, which were derived from a review of curricula in existence nationwide, are presented for each alternative approach. Additionally, a supplementary document entitled *Solar Energy Technology: Supplementary Curriculum Materials* and compiled by Conserva, Inc., is available for review from the East Central Curriculum Coordination Center in Springfield, Illinois. The document consists of curriculum outlines, course descriptions and course syllabi obtained from a variety of sources.

Associate Degree Program

The types of existing curricula leading to an associate degree in solar energy technology vary in their scope and emphasis. Some curricula maintain an intensive solar emphasis; i.e., the information presented in the courses that are offered pertains directly to solar technology. For instance, skills and technical knowledge in such areas as electrical controls and circuitry, sheet metal fabrication and engineering math are taught in solar engineering courses with specific reference to their application in solar system design and installation. In contrast, other curricula draw heavily upon related courses or curricula in teaching the skills and technical knowledge mentioned above; a course from the electronics curriculum is used for preparing students in electrical controls and circuitry, and a general math course from the mathematics curriculum provides instruction in the basic skills and theory required for sizing and installing solar systems. Existing curricula which can lend support to or provide a foundation for a solar energy technology curriculum are physics; plumbing; heating, refrigeration and air conditioning; engineering; carpentry; electronics; sheet metal works; mathematics; and computer programming.

Within the range of associate degree curricula, those with intensive solar emphasis are most suitable when a majority of the employment opportunities for solar energy technicians exists in companies dealing exclusively in solar systems. In these situations, graduates work as full-time solar technicians with little need for tangentially related skills in plumbing, construction and heating, air conditioning and refrigeration — except where they are directly applicable to solar system design and installation. However, an intensive specialization in solar technology requires greater institutional expenditures, for such resources as instructional staff, specialized classrooms and laboratory facilities and equipment.

Curricula which rely on other disciplines (heating, air conditioning and refrigeration, plumbing, engineering, physics, etc.) for much of their basic coursework are most appropriate where sufficient demand for solar technicians is evidenced in non-solar as well as solar firms. A survey of potential employers may indicate the need for technicians with solar skills in related industries such as heating, air conditioning and refrigeration, plumbing and construction. If this is the case, students in a solar technology curriculum would need instruction in the additional skills and technical knowledge required for employment in the related industries.

The two-year curriculum presented below represents a synthesis of available information on associate degree curricula in solar energy technology. It is designed to prepare solar technicians cabable of designing, sizing, installing, conducting performance checks on and repairing solar heating and cooling systems. In addition, the curriculum will prepare students in the basic installation and maintenance skills of the related field of heating, refrigeration and air conditioning.

Based on information obtained through earlier program development steps (e.g., determining employer needs and

employment opportunities, refining job competencies), the suggested curriculum can be adapted to suit area or regional needs and characteristics. Additionally, modifications may be necessary in order that the suggested curricula conform to institutional resources or requirements.

Solar Energy Technology Courses	Semester Credit Hours
Basic Solar Systems	3
Solar Systems Design and Layout	3
Solar System Installation	3
Solar System Maintenance	3
Solar Feasibility Cost Analysis	3
Design Project	4
Introduction to Photovoltaic and Wind Energy	3
Cooperative Work Experience or Practicum (optional)	3 - 6
Related Science and Technical Courses	
General Math I	3
General Math II	3
Physics I	3
Physics II	3
Computer Programming	3
Fundamentals of Electricity	3
Electrical Controls and Circuitry	3
Blueprint Reading	2
Engineering Drafting	3
Soldering and Brazing	2
Sheet Metal Fundamentals	3
Basic Refrigeration Fundamentals	3
Domestic Heating and Air Conditioning	3
General Education Courses	
Suggested Electives in Communication Skills/Technical Report Writing/ Human Relations	9 - 12
TOTAL CREDITS	68 - 77

Basic Solar Systems. This course lays a foundation for the study of solar energy technology and introduces the various types of solar systems and system components. A brief history of the emergence of solar science is presented along with a survey of methods for solar heating, cooling and domestic hot water. Students receive an overview of the different types of collectors, storage units, heat transport mediums and passive and active systems.

Solar System Design and Layout. Integration of solar systems with existing conventional heating and cooling systems is the main focus of this course. Practical considerations of integration and keeping the system in harmony with architectural structures are discussed as well as geographic and situational factors affecting the selection of collectors and other system components. Students gain lab experience in the practical aspects of the course, including determining the optimum system size and calculating heat loads and system performance in given geographic locations.

Solar System Installation. Through hands-on training, students acquire the necessary manipulative skills for installing solar system hardware. Included among these skills are mounting all types of collectors, installing storage units, connecting pipes and ducts, installing heat exchangers, pumps, valves and filters and connecting the system with the back-up unit. On a small scale, students are involved in connecting electrical and electronic devices in the control system. In addition, an overview of local building codes and ordinances is presented. The course serves to integrate all previously learned skills relative to installation.

Solar System Maintenance. Actual system working conditions are duplicated in the laboratory to provide the opportunity for troubleshooting, diagnosing and repairing system malfunctions. Among the skills taught are determining heat loss, performing maintenance checks and system start-ups, and repairing motors, pumps, blowers, coils and controls.

Solar Feasibility Cost Analysis. This course is designed to instruct students in figuring the initial cost of installation, payback, reversals, maintenance cost, tax credit, energy cost evaluation averages and back-up system costs. Instruction in the use of computer programs for cost comparison and analysis is given.

Design Project. This course is devoted to the integration of all previously acquired knowledge and skills. The student designs a complete solar system for residential or commercial use, serving as the interface between the architect and engineer. The student selects the proper system type, determines the optimum size, calculates system performance and integrates the system with architectural design and the existing conventional heating or cooling system. The result is a set of working papers including drawings, charts, tables and installation and maintenance details necessary for the successful installation and operation of the solar system.

Introduction to Photovoltaic and Wind Energy. Other forms of energy conversion are presented with the emphasis on photovoltaic cells and wind power. The course explores state-of-the-art hardware and its application as well as new directions in energy use for the future.

Cooperative Work Experience or Solar Practicum. Students gain practical experience in the design, installation and maintenance of solar systems. Under direct supervision students receive on-the-job refinement of the theories and principles learned in the classroom at selected industrial or business settings. (Optional)

General Math I and II. These two courses present the basic principles of trigonometry, college algebra and geometry most applicable in solving design problems. Concepts covered include graphs, quadratic equations, right triangle trigonometric functions, exponents, logarithms, right triangle calculations, vectors and other topics.

Physics I and II. The basic study of the properties of heat, structures and fluids is the focus of these two courses. Topics presented include materials that prevent and facilitate heat transfer, factors affecting fluid flow, the way in which forces act upon structures and frames, and the practical applications of mechanics in design and construction work.

Computer Programming. Basic programming of microcomputers is introduced through the use of BASIC and ASSEMBLY LANGUAGE. Digital computer fundamentals, the flow of control and the verification and debugging of problem-oriented programs are among the topics covered. Hands-on experience is provided in all aspects of the course.

Fundamentals of Electricity. Instruction is given in the basic principles of electricity, including atomic structure, protons, neutrons and electrons and their relationship to conductors, insulators and semi-conductors. Ohm's Law, Kirchoff's Law, circuits and schematic wiring diagrams are

studied along with AC and DC and some types of motors and relays. A lab accompanies the course to provide practical work with electrical circuits.

Electrical Controls and Circuitry. This course emphasizes the study of motors, switching devices, timers and other electrical components used in environmental controls. Students are further instructed in how to read and use schematic diagrams and wiring diagrams. The lab work is closely coordinated with the lecture in order to develop skills in the practical application of theory, such as building and troubleshooting basic circuitry and wiring relays, timers and compressors.

Blueprint Reading. Skills in interpreting blueprints and trade specifications, symbols and abbreviations common to the building trades, such as plumbing, heating, electricity, carpentry and masonry are taught. Proficiency in drawing plans, elevations and 3-view pictorial sketches is developed.

Engineering Drafting. Through this course of study students become competent in the use of drafting instruments, lettering, sketching and dimensioning. Students are involved in drawing 3-view orthographic projections and pictorial views.

Soldering and Brazing. Techniques of soft soldering, aluminum soldering, and aluminum and steel brazing are taught.

Sheet Metal Fundamentals. The basic principles of sheet metal fabrication as they apply to the heating and cooling and solar energy industries are introduced. In addition, the course covers safety measures and the basic tools and equipment of the trade. Students are provided with practical experience in the fabrication of ducts and transition pieces most frequently encountered in home and commercial installations.

Basic Refrigeration Fundamentals. This course is an introduction to refrigeration theory and the construction, operation and servicing of refrigeration systems. The fundamentals of vapor compression and absorption, pressure-temperature relationship, gas laws and characteristics of refrigerants, compressors, evaporators and condensors are among the topics covered. Laboratory work provides students with the opportunity to apply the principles learned.

Domestic Heating and Air Conditioning. Students receive instruction in the basic principles of air flow and the various types of heating and air conditioning equipment used in the industry. Training and practical lab experience in diagnosing system malfunctions and calculating cooling and heating loads are provided.

Certificate Program

A certificate program is another viable alternative for preparing solar energy technicians. Typically, certificate curricula require some prerequisite skills and knowledge in such areas as heating, air conditioning and refrigeration; plumbing; math; and physics. As a result, certificate curricula generally emphasize the acquisition of solar-related skills, at the expense of coursework in related technical areas and general education courses. The curriculum thus is most appropriate when the potential student population consists of individuals employed or trained in related trades or technical fields.

Below is a suggested curriculum in solar energy technology designed from the associate degree curriculum presented earlier. Course descriptions can be reviewed by referring to the section containing the associate degree curriculum.

Solar Energy Technology Courses	Semester Credit Hours
Basic Solar Systems	3
Solar System Design and Layout	3
Solar System Installation	3
Solar System Maintenance	3
Solar Feasibility Cost Analysis	3
Design Project	4
Introduction to Photovoltaic and Wind Energy	3
Related Technical Courses	
Basic Refrigeration Fundamentals	3
Domestic Heating and Air Conditioning	3
General Math I	3
Physics I	3
General Education Courses	
Communication Skills (suggested)	3 - 6
TOTAL CREDITS	37 - 40

Heating, Refrigeration, and Air Conditioning Curriculum: Solar Technology Option

Surveys of student needs, employment demand and labor market characteristics may lead to the establishment of a solar energy option or emphasis within a more conventional associate degree curriculum such as heating, air conditioning and refrigeration. In situations where the demand for solar technicians is evidenced in industries such as heating and air conditioning and plumbing companies, rather than solar firms, or in regions with a significant fluctuation in demand, it may be advantageous to provide students with a broader range of skills. This would allow graduates greater flexibility in gaining employment and provide them with employable skills should the emphasis in the solar market shift.

Rubinstein and Ramsey (1977), in a study conducted by National Evaluation Systems, advocate that, pending the firming up of purely solar job opportunities, training should be directed at producing workers skilled in more conventional occupations in order to assure employment. The Solar Energy Task Force supports this position. In following this advice, institutions may offer students the option to specialize in solar technology while satisfying the basic requirements of a parent curriculum. This would prepare students for entering the labor market as qualified workers in the heating, air conditioning and refrigeration industry (for example) with additional skills that would enable them to function in a solar energy technician capacity.

San Jose City College in San Jose, California, offers a solar technology curriculum that provides training in the basic air conditioning and refrigeration skills while conjunctively emphasizing training in solar-related skills. The air conditioning and solar technology curricula are essentially the same with the exception of a substitution of solar courses for a few of the more advanced air conditioning courses. The curriculum and course descriptions for the solar technology program are presented below.

Solar Energy Technology Courses	Semester Credit Hours
Solar Energy - Residential Applications	3
Solar Energy - Industrial Applications	3
Solar Photoelectric Conversion	3

Related Science and Technical Courses	Semester Credit Hours
Technical Physics	3
Physical Science - Solar Theory	3
Trigonometry	3
College Algebra	3
Air Conditioning Principles - Electrical	4
Air Conditioning Principles	4
Refrigeration Principles - Heat Transfer	4
Hydronics - Heat Transfer, Fluid Flow	3
Applied Piping and Drawing	4
Commercial/Industrial Controls	2
General Education Courses	
History, Government, Humanities, English, Speech, Physical Education Activity, Ethnic Studies, Health Education	21
TOTAL CREDITS	63

Solar Energy-Residential Applications. Theory and development of solar energy applications for residential use are considered in this course. Students learn the necessary skills for designing solar systems for residential application, residential hot water systems and pool heating systems. Also provided is an analysis of flat-plate collector design and application. Students learn to operate and service a solar laboratory system.

Solar Energy - Industrial Applications. This course is a study of industrial applications of solar energy for use with heating, air conditioning and refrigeration systems. Topics include absorption refrigeration, heat pumps, heat reclamation systems and Rankine cycle turbines and generators.

Solar Photoelectric Conversion. The theory, development, application and future use of photoelectric conversion are the topics of this course.

Air Conditioning Principles - Electrical. This course involves the study and discussion of the various types of air conditioning equipment used in industry, as well as an analysis of the properties of air and how these properties are controlled to produce a conditioned space. Students learn to draw and interpret schematic wiring diagrams related to air conditioning control. The course also introduces load calculations and psychrometrics. Students are involved in laboratory projects which follow the lectures and provide an application of theory.

Air Conditioning Principles. A more comprehensive study of psychrometrics, load calculations and equipment selection for heating and cooling is presented in this course. It includes an analysis of the interrelationships of various components in industrial systems and a survey of building layout for installation of equipment and controls. Three phase power applications of industrial control systems are introduced.

Refrigeration Principles - Heat Transfer. This course introduces the tools, fittings and materials involved in the construction and servicing of refrigeration systems. The fundamentals of vapor compression and absorption systems, characteristics of refrigerants, compressors, heat exchangers, metering devices, evaporators and condensors are presented. Gas laws and basic thermodynamics are also covered.

Hydronics - Heat Transfer, Fluid Flow. This course deals with the design and installation of hydronic systems for heating and air conditioning. It considers the details of steam-heated water and chilled water systems. Boiler and pump selection are also covered.

Applied Piping and Drawing. Drafting principles as applied to piping, refrigeration and mechanical systems in air conditioning are the topics of this course.

Commercial - Industrial Controls. This course provides a study in control theory. It introduces the basis of electronic, pneumatic and fluidic controls as utilized in the air conditioning and refrigeration industry.

Summary

The above discussion focuses on three viable alternatives to vocational technical preparation of individuals in solar energy technology. It is not intended to represent an exhaustive survey of methods currently used nor the realm of possibilities for preparing solar technicians. However, the alternatives presented do provide several foundations for establishing a solar energy technology curriculum.

An accompanying document (*Solar Energy Technology: Supplementary Curriculum Materials*) contains sample curriculum outlines, course descriptions and course outlines obtained from vocational-technical schools across the country. Represented among these are additional examples illustrating the three alternatives presented above and variations of those alternatives. It is readily apparent from these sample curricula that institutions offering instruction in heating, air conditioning and refrigeration can easily adapt or expand their curricula to include a solar technology emphasis. In establishing a solar technology curriculum, it may be more prudent and/or economically feasible to begin by expanding an existing air conditioning, refrigeration and heating curriculum as illustrated in the section on solar technology options rather than to initially adopt the suggested associate degree curriculum presented in this report. Additional solar technology courses can gradually be offered as the need arises and as more resources become available.

Included also in the accompanying document are information sheets and curricula or schedules for a few of the workshops that have been offered in solar technology. The workshops were designed for attendance by skilled workers in the building, heating and air conditioning and plumbing trades. Their purpose was to develop practical skills in installation and maintenance within a limited period of time (typically five days).

Another mode of solar energy technology instruction used by some community colleges is continuing education. Both the general purpose of this type of instruction and the type of students it was designed to accomodate are similar to that of the workshops. The continuing education courses in general satisfy the demand made by employed individuals for training in solar-related skills.

There are a number of ways vocational institutions can satisfy the need for training in solar technology. However, the most suitable alternative will be apparent only after determining area employment opportunities and employer needs and student interests and assessing institutional resources.

V. RESOURCE REQUIREMENTS

Presented in this chapter are the resources required to implement a curriculum in solar energy technology. The first section outlines the composition of a curriculum advisory committee. This is followed by discussions of the facilities and equipment and instructor resources needed to implement a curriculum in solar energy technology. These two sections will be useful in (1) determining whether an institution possesses the resources essential to a solar technology curriculum and (2) planning for the acquisition of needed resources.

Curriculum Advisory Committee

Though a curriculum advisory committee performs almost entirely in an advisory capacity, its input to program development and maintenance is often critical. As noted in Chapter II, the advisory committee participates in most of the curriculum developments in the field which require curriculum modifications, evaluating the performance of graduates and recommending curriculum modifications based on the evaluation, and serving as a link between the school and the community.

Advisory committee membership should represent the various disciplines which contribute to and benefit from solar energy technology. Both employees and employers are desirable on a committee. Additionally, if consistent with institutional policy, faculty representing the heating, refrigeration and air conditioning, physics and building trades curricula should be represented on the committee. After the curriculum has been operational, a graduate of the solar technology curriculum and a current student should be invited to serve as members. Typically, membership ranges from six to twenty representatives; however, eight to twelve can be considered a reasonable size for a committee. The following list identifies potential representatives for a solar energy technology curriculum advisory committee.

- Heating, Refrigeration and Air Conditioning Faculty
- Physics Faculty
- Construction Trades Faculty
- Students
- Program Graduates
- Solar Technicians
- Architects
- Mechanical Engineers
- Representatives of solar firms or contractors
- Representatives of solar equipment manufacturers
- Members of local building and trade industries
- State and local energy agency representatives
- Labor organization representatives
- Members of related local associations or organizations
- Vocational Specialists
- Curriculum Planning Specialists

Facilities and Equipment

Facilities required for implementing a curriculum in solar energy technology include standard classrooms (equipped with teaching aids) and adequate laboratory space required to support solar energy technology and related technical coursework. An equipped laboratory is essential for preparing students to be proficient in the manipulative skills and technical knowledge required for solar technicians. A substantial investment in equipment and instruments is required to create an adequately furnished laboratory or solar technology training facility. In their consideration of equipment needs for solar technology programs, the Solar Energy Task Force members concluded that a $20,000 investment could produce "an effective solar laboratory" (*Task Force Report*, 1978). However, it is not necessary that the total amount be expended before the onset of a solar technology curriculum. Equipment purchases can be extended over a period of time to alleviate the one-time financial burden at startup.

Equipment expenditures can be minimized by utilizing some of the equipment and instruments of other curricula. Heating, air conditioning and refrigeration and the building trades curricula are resources for such items as hand and power tools, pumps, torches, welding equipment, insulation, piping, ducting, etc. However, the major expenditures are involved in purchasing the equipment unique to solar technology. Types of equipment most commonly found in solar technology training facilities are collector arrays (liquid and air, flat plate and concentrating), domestic hot water heating systems, storage units and miscellaneous equipment, such as voltmeters, flow meters, glazing materials, pumps, valves, antifreeze, etc.

Presented in Appendix E of this report are detailed lists of equipment currently in use or proposed for use from five community colleges and technical institutions. Among the five, equipment costs range from $21,000 to $72,000. In a supplementary document compiled by CONSERVA, Inc. and entitled *Solar Energy Technology: Equipment/Training Aids/Audio Visuals*, catalogs of equipment for commercial use and for educational purposes are presented. (This document is available for review from the East Central Curriculum Coordination Center in Springfield, Illinois.) These may provide additional information on what is currently available and in use in solar energy equipment.

Because new developments are continually being made in the solar technology field, laboratory equipment has not become standardized. Therefore, it is imperative that instructors in the solar energy curricula keep abreast of the changes. The assistance of the curriculum advisory committee is valuable in this regard, as well as in the determining priorities for equipment purchases. Other sources of information concerning new developments in solar technology are the equipment manufacturer catalogs and related journals and periodicals. A list of journals and periodicals is presented in Appendix F.

Instructor Qualifications

A diversity of academic and field experience is evidenced in those individuals involved in solar technology instruction. By nature of the industry, a range of skills are needed to provide comprehensive, quality training to students enrolled in solar technology programs. The basic prerequisite for instructors is knowledge of or field experience in solar technology. Other skill requirements may vary with the emphasis of the curriculum. For instance, institutions offering curricula which stress the design aspects of solar technology may seek instructors with degrees and experience in mechanical engineering. Programs geared toward producing technicians

qualified in installation, maintenance and heating, air conditioning and refrigeration skills would employ persons with related experience in the building trades as instructors. Other desirable qualifications also include functional knowledge of physics (heat), general mathematics, computer skills and electronics.

One means of fulfilling such diverse requirements for instructors is to retain one individual who is highly qualified and experienced in solar energy technology as coordinator/instructor, in addition to several part-time or full-time instructors from the various other fields. The support instructors may be drawn from other programs to teach the more traditional courses, as well as to assist in instructing the solar technology courses. The number of instructors needed would depend upon the number of students enrolled in the program. Typically, one full-time solar technology instructor is required for each 20 - 30 students.

VI. ABSTRACTS OF CURRICULUM MATERIALS

Although solar energy technology is a new and emerging field, there have been a number of comprehensive and authoritative volumes produced on the subject. This section contains abstracts of a number of these volumes, specifically instructional and curriculum materials that were identified during the process of procuring curriculum information from proposed or existing nationwide programs. The abstracts are presented in two major categories: instructional materials and curriculum materials. They are further classified within each category as follows:

Instructional Materials
- Text or References
- Training Manuals
- Codes and Standards
- Audiovisuals

Curriculum Materials
- Curriculum Guides
- Bibliographies
- Catalogs
- Directories
- Technical Reports

The abstracts do not represent comprehensive coverage of all available instructional resources. They primarily consist of those recommended by the solar technology personnel contacted.

It is critical that instructional materials be kept current in order to provide quality training. As equipment changes or becomes obsolete, so do installation and maintenance instructions. Thus, training manuals developed by manufacturers of solar components must be kept up to date. Additionally, at this writing, several additional solar technology texts or references are in production, possibly containing more current information on the state of the art of solar technology.

While the abstracts presented here provide a good foundation in terms of available instructional materials, the reader is advised to keep informed of current literature and new developments. Preparation for employment in the field of solar technology and the development of the industry are still in the embryonic stage. Changes are occurring rapidly, which necessitate keeping abreast of new applications and developments in the field. This need is particularly acute for those persons involved in the instruction of future solar technicians. One means of keeping abreast is to subscribe to relevant journals and periodicals. These sources may also provide supplemental material for courses. A list of solar-related journals and periodicals is presented in Appendix F.

INSTRUCTIONAL MATERIALS

Title: APPLICATIONS OF SOLAR ENERGY FOR HEATING AND COOLING OF BUILDINGS
Authors: Richard C. Jordan and Benjamin Y.H. Liu (Editors)
Publisher: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
(ASHRAE Publications Sales Department)
345 East 47th Street
New York, NY 10017
Year: 1977
No. of Pages: 206
Cost: $8.00 (Non-members)

This volume represents a revised version of the 1967 publication, *Low Temperature Engineering Application of Solar Energy*. This previous work was expanded to include several new technical contributions. The thirteen chapters that comprise the document are divided into three sections. The first section covers environmental evaluation and solar assessment. Contained within this section is a brief historical overview; the legal, political, social and ecological considerations of solar energy applications; and an assessment of the available solar radiation. Section two concerns the performance and rating of system components and includes coverage of solar collector surfaces, storage units, solar collector performance, simulation of solar performance and the testing and rating of solar collectors. The third section presents information on the direct application of solar energy. Three major topics are covered here: solar water heaters, solar space heating and solar space cooling. Metric conversion to SI units are provided either parenthetically or at the end of each chapter through the use of conversion factors.
TEXT OR REFERENCE

Title: APPLIED SOLAR ENERGY
Authors: Aden B. Meinel and M.P. Meinel
Publisher: Addison-Wesley Publishing Company, Inc.
Reading, MA 01867
Year: 1976
No. of Pages: 651
Cost: $20.95

This book is part of the publisher's series in physics and is intended primarily for seniors and graduate students in energy conversion courses, although it has been used at the community college level. Detailed, technical discussions are restricted to thermal conversion; however, a number of related areas are touched upon, such as direct conversion through solar cells. The authors attempt to satisfy laypersons and engineers. For potential users of solar energy, the essentials are summarized and a chapter on simple order-of-magnitude calculations for answers to typical questions are provided. Several chapters deal with current research in the field of solar energy, detailing the results and questions that have evolved from it.

The text begins with an historical overview of solar applications. Chapters 2 and 3 deal with the sun as an energy resource and cover such topics as solar flux and weather data and the availability of solar energy. In chapters 4 through 8 the optics involved in solar collectors and the ways in which various types of collectors utilize them are discussed. Chapters 9 through 13 detail the absorption of solar energy through selective surfaces, the basic elements of heat transfer and how it occurs in solar collectors, flat-plate collectors and energy storage. The remaining three chapters deal with the utilization and application of solar energy. The twenty-two appendices provide useful information such as conversion tables, solar flux quantities and collector performance figures.
TEXT OR REFERENCE

Title: ASHRAE JOURNAL — SOLAR TECHNOLOGY UPDATE '78
Author: W.G. Edmond Gutman (Editor)
Publisher: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.
(ASHRAE Publications Sales Department)
345 East 47th Street
New York, NY 10017
Issue: November, 1978
No. of Pages: 128
Cost: $2.00

This special issue of the *ASHRAE Journal* is devoted solely to solar energy. It features articles on solar research, the solar industry, solar energy in the political arena, recent developments in the field and new applications of solar energy. The following is a list of contributing authors and their articles:

- Solar: Mankind's Ultimate Energy Frontier?
  by W.E. Gutman
- The Solar Industry: Catching Its Breath
  by Bruce Anderson
- Solar Energy: Present and Future
  by Stanley F. Gilman
- Urban Planning and the Solar Habitat
  by Michael Kogan
- What's Happened to Solar Research?
  by Peter J. Lunde
- A View from Capitol Hill
- Program Opportunity Notice: Feds Pledge $4 Million to Solar
- The Meaning and Use of Consensus Standards in Rating and Certification of Solar Collectors
  by Alwin B. Newton
- Passive Solar Systems—Not So "Passive" Anymore
  by John I. Yellott
- Solar Experiments with Passive Retrofit
  by Scott F. Keller, Arthur V. Sedrick and William C. Johnson
- Window Treatment and the Retrofit Market
  by Donald R. Wulfinghoff
- Solar Water Heating System Design for a Research Lab
  by Thomas L. White and Burt Swerdling
- ARI: 25 years of Dedicated Service
  by W. Stephen Comstock

TEXT OR REFERENCE

Title: DESIGNING AND BUILDING A SOLAR HOUSE
Author: Donald Watson
Publisher: Garden Way Publishing
Charlotte, VT 05445
Year: 1977
No. of Pages: 281
Cost: $8.95

In this book the author describes alternative methods of solar heating. Details on their appearance, performance and cost are given so that comparisons can be made as applicable to individual circumstances. Chapter 1 provides an historical overview of solar house design and solar energy applications. Chapters 2 through 5 present the basic approaches and principles of operation of passive and active solar heating. The author describes how particular types of solar equipment fit into the overall heating-system design. Chapter 6 illustrates how solar heating is part of a total approach to energy conservation in building and identifies the principles and practices of "ecodesign." The remainder of the book was intended for the reader interested in applying the principles to the design and construction of a solar house. Chapter 7 compares six alternative approaches to solar house heating on the basis of their economic return in four northern climates. In order that readers can perform their own evaluations of the alternatives based on factors particular to their situations (climate, installation cost and financing charges), there are methods for solar design calculations provided in an appendix. The basic steps in planning a solar house project are described in Chapter 8, including site planning, design and construction. Checklists are provided of important points to consider during each of these steps. The chapter is written with the owner/builder in mind and, therefore, includes potential problems that may be encountered. Throughout the book, the text is illustrated with photographs and drawings depicting examples of solar houses. The appendices include selected solar houses in the United States, solar designers, architects and engineers and sources of solar heating equipment.
TEXT OR REFERENCE

Title: DIRECT USE OF THE SUN'S ENERGY
Author: Farrington Daniels
Publisher: Ballentine Books, Inc.
400 Hahn Road
Westminster, MD 21157
Year: 1974
Publisher: Yale University Press
92 A. Yale Station
New Haven, CT 06520
Year: 1964
No. of Pages: 373
Cost: $ 1.95 (paperback)
$17.50 (hardbound)

Through this book, the author intended to encourage research in solar energy. Engineering and technical details are kept to a minimum for the non-specialist reader; however, bibliographies are provided at the end of each chapter which direct the interested reader to sources of technical information. The book makes a case for the use of solar energy, as opposed to conventional sources of energy such as fossil fuel, despite higher initial capital investment. The reasons supporting this argument are the rising demand for energy, the rapid depletion of irreplaceable fossil fuels and the fact that continued advances in solar technology and rising fuel prices are making it more practical to install solar systems for use in the home. However, the author maintains that further research is necessary to make solar energy a truly competitive source of power.

The book provides information on the availability of solar energy and how to measure it; various solar collectors; applications of solar energy including solar cookers, solar water heaters, the use of solar energy in drying agricultural crops, solar home heating and cooling, and the use of solar energy in the distillation of sea water; three methods of converting solar radiation into electrical power; and the storage and transportation of solar energy.
TEXT OR REFERENCE

Title: ENERGY SOURCES AND CAREERS: SOLAR ELECTRIC AND SOLAR THERMAL
Author: Megatech Corporation
Publisher: Megatech Corporation
Billerica, MA 01866
(612)273-1900
Year: Undated
No. of Pages: Volume 1 — 18, Volume 2 — 25
Cost: $13.95 for volumes 1-6

Energy Sources and Careers is a series of publications intended to introduce the subject of alternative energies. Solar Electric and Solar Thermal are the first two volumes in the series and present information on the availability of the source of solar energy, the method of power production, the environmental impact and careers in these fields. The volume on solar electric describes solar cells, their construction, operation and uses. The volume on solar thermal discusses how to estimate total energy, monthly variations in the availability of solar energy and the components of a solar system.
TEXT OR REFERENCE

Title: F-CHART WEATHER AND RADIATION TABLES
Author: Lennox Industries, Inc.
Publisher: Lennox Education Products
P.O. Box 400450
Dallas, TX 75240
Year: Undated
No. of Pages: Non-paginated
Cost: $29.00

This document consists of tables providing monthly average weather and radiation data for typical cities across the United States. These data are used in calculating optimum size and designing systems.
TEXT OR REFERENCE

Title: FUNDAMENTALS OF SOLAR HEATING
Author: Sheet Metal and Air Conditioning Contractors National Association
Publisher: U.S. Department of Energy
Solar Technology Transfer Branch
600 E Street, NW
Room 400
Washington, DC 20545
Year: 1978
No. of Pages: 152
Cost: $9.08 (printed copy)
$3.00 (microfiche)
No charge to Educators

This book and its companion study guide are designed for use in a home study course for heating, ventilating and air conditioning contractors. However, it could be useful to teachers of adult education technical courses. The two books are designed to serve as a programmed instructional system which provides immediate feedback on how well the information is understood and/or applied. The book contains eleven lessons complete with learning objectives, review tests, and unit examinations. Unit 1, which includes the first two lessons, presents a basic overview of passive and active heating systems, solar cooling and the economic considerations which influence solar installation and solar radiation. Unit 2 is concerned with the components of a solar system; lesson 3 discusses solar collectors (flat plate and concentrating); the major topic of lesson 4 is the heat storage unit; and lesson 5 covers the various kinds of control devices and specialty items needed for solar-assisted heating systems, such as pumps, fans and heat exchangers. Unit 3, lessons 6-8, presents information on sizing procedures for solar components, the operation of the more common types of air and liquid systems and the three basic types of solar domestic water heating systems. Unit 4, lessons 9-11, provides information about installing and servicing solar-assisted heating systems and discusses some of the legal concerns associated with new construction or existing structures being retrofitted.
TEXT OR REFERENCE

Title: JOHN BARLING'S SOLAR FUN BOOK: 18 PROJECTS FOR THE WEEKEND BUILDER
Author: John Barling
Publisher: Brick House Publishing Company
3 Main Street
Andover, MA 01810
Year: 1979 (This book will be published and available for resale at the end of August, 1979.)
No. of Pages: 112
Cost: $7.95

This book provides a simple, do-it-yourself guide to building solar devices. It includes a number of practical and demonstration projects for illustrating some of the practical applications of solar energy. The projects were developed for use in teaching the basic principles of solar energy to junior high school students. However, their application extends beyond the junior high level to anyone interested in practical applications of solar energy. Each project is detailed with step-by-step instructions, line illustrations and a list of materials. The book emphasizes the use of recycled materials wherever possible, such as discarded printing plates, a refrigerator heat exchanger and sheet metal. The solar projects included in this document represent various types of cooking devices, water and air heaters, food-producing devices and experimental solar devices. Below are some examples of the projects:

- Chicken cooker
- Greenhouse
- Glass solar still
- Solar wood igniter
- Barrel bread box heater
- Food dryer
- Hot dog cooker

TEXT OR REFERENCE

Title: PRINCIPLES OF SOLAR ENGINEERING
Authors: Frank Kreith and Jan F. Kreider
Publisher: McGraw Hill Book Company
College Division
Manchester Road
Manchester, MO 63011
Year: 1978
No. of Pages: 778
Cost: $24.50

"Intended to serve the needs of a wide-ranging audience from senior undergraduate students [in engineering] to practicing engineers, this work provides a teaching framework for the design and analysis of successful energy conversion systems. Combining a basic technical understanding with an appreciation of the economic aspects of utilizing nonrenewable energy sources, the authors present the results of pioneering research work in the problems of solar energy conversion. Beginning with the fundamentals of heat transfer and solar radiation, this text proceeds to applications that stress systems analysis and modeling with component interactions. Included are detailed thermal and optical analyses of ten solar collector types, both concentrating and nonconcentrating, assessments of the economic impact of solar systems through discounted cash-flow analysis and optimization. Practical examples are provided throughout to illustrate principles and concepts as they are presented. Extensive appendices offer recent data on isolation and availability of solar radiation, solar and weather maps, and tables of required mathematical functions and thermophysical properties. All basic material is in SI units, with some solved problems in English units for the working engineer." (Publisher Review)
TEXT OR REFERENCE

Title: SOLAR CELLS
Author: Charles E. Backus
Publisher: The Institute of Electrical and Electronic Engineers Press
345 East 47th Street
New York, NY 10017
Available From: John Wiley and Sons, Inc.
Eastern Distribution Center
1 Wiley Drive
Somerset, NJ 08873
Year: 1976
No. of Pages: 504
Cost: $12.45 (paperback)

This book is a compilation of 42 selected papers in the field of solar cells or photovoltaic energy converters. Although it provides the reader with comprehensive material on solar cells, the book would not be suitable as a text in a solar energy technology curriculum due to the advanced nature of the subject matter and the way in which it is presented. However, this document would serve as a useful resource for instructors, particularly for the more advanced courses in photovoltaic energy. The papers are classified under five major categories: general review, solar cell theory, cell fabrication, space systems and terrestrial applications. Appended to the document are proceedings of the 1973 workshop on photovoltaic conversion and a 77 page bibliography containing other sources of information on photovoltaic energy.
REFERENCE

Title: THE SOLAR DECISION BOOK
Author: Richard H. Montgomery
Publisher: John Wiley and Sons, Inc.
Eastern Distribution Center
1 Wiley Drive
Somerset, NJ 08873
Year: 1978
No. of Pages: 306
Cost: $12.95

The purpose of this book is to present within one source the necessary information for making intelligent decisions concerning the design and use of practical solar systems. The information reported in this document has been proven in the field. The book is not organized around chapters, but a series of "decisions" that individuals must make in buying or building solar heating systems. Following the logical sequence of when they would be encountered in building and design process, twenty-one decisions with background information are detailed. Pre-system design decisions cover the following topics: the energy shortage, individual energy needs and costs, energy conservation, alternate energy sources, the sun as an alternate source of energy, solar energy systems as an investment and negotiating the loan. The remaining decisions deal with design and installation, including the selection of appropriate components, and include information on the following: impact of the system on energy costs, collector sites, flat-plate collectors, liquid heat transfer mediums, pumps, heat exchangers, storage units, auxiliary heaters, heat-delivery systems, system controls, the "best" investments, system size, job price and installation. Appendices provide the reader with aids for solar system design work, such as methods for calculating structure heat loss, evaluating energy conservation investment, sizing the solar collectors and plotting shade on solar window projections, Also, conversion tables for various units are included.
TEXT OR REFERENCE

Title: SOLAR ENERGY AND BUILDING
Author: Steven V. Szokolay
Publisher: John Wiley and Sons, Inc.
Eastern Distribution Center
1 Wiley Drive
Somerset, NJ 08873
Year: 1975
No. of Pages: 174
Cost: $18.50

"This book summarizes, at a level of discussion set to suit architects and other non-specialist readers, the nature of the possibilities offered in this crucial sphere. Restricting mathematical treatment to essentials, it begins by establishing the context of solar energy utilization (the global energy problem) and reviewing some of the physical problems. The methods of collecting solar energy are then surveyed, discussing thermal collection in some detail. A substantial chapter is devoted to the various uses of solar energy, with an emphasis on water and space heating. The chapter on "sun and building" suggests that a well designed building is itself a solar collector device — the various installations will only improve its performance and provide a greater flexibility of controls.

"The core of the book contains an illustrated technical review of some thirty "solar houses" from all over the world, complete with all published details and performance data. This is followed by a brief discussion of planning implications, an analysis of economic factors and a survey of the existing "solar industry." Finally an attempt is made to provide a design guide.

"The book is not a do-it-yourself manual, but it provides enough information for the growing number of architects and technically interested laypersons who are considering installing solar energy collectors to get to grips with the basic problems involved." (Publisher Review)
TEXT OR REFERENCE

Title: SOLAR ENERGY EXPERIMENTS
Author: Thomas W. Norton
Publisher: Rodale Press, Inc.
33 E. Minor Street
Emmaus, PA 18049
Year: 1977
No. of Pages: 129
Cost: $5.95

"This is a multipurpose manual comprising eighteen experiments and eight classroom-type activities. The eighteen experiments are of varying difficulty and cover the important aspects of solar energy utilization. Each experiment is self-contained, with its own introduction and background information, making this book a suitable solar energy curriculum outline.

"Energy measurements are emphasized, and techniques for collector efficiency determinations are considered. Among the topics discussed are altitude and azimuth of the sun, radiation characteristics, energy collection with converging lenses, air and water solar collectors, and energy storage in gravel beds and in salt hydrates. Both theoretical and practical engineering considerations are illustrated by the experiments. Many experiments are directly applicable to existing physics, general science, and environmental science curricula, while others are of sufficient difficulty and duration to challenge college students and the most advanced secondary students.

"The eight classroom-type activities present worldwide energy data and solar energy data for individual student analysis. As a result, this manual can serve as a useful classroom resource as well as a general reference source." (Author's Abstract)
TEXT OR REFERENCE

Title: SOLAR ENERGY:
FUNDAMENTALS IN BUILDING DESIGN
Author: Bruce Anderson
Publisher: McGraw Hill Book Company
College Division
Manchester Road
Manchester, MO 63011
Year: 1977
No. of Pages: 374
Cost: $21.50

This book provides a practical guide for designing a solar structure, evaluating the solar design work of others and evaluating products being sold by manufacturers. It serves as a reference for such information as:

- how to achieve maximum energy-conserving designs;
- easy-to-use rules for making decisions about construction methods, materials, and equipment; and
- the proper use of windows, with specific recommendations for selecting types of glass.

The author discusses major methods of using solar energy for heating and cooling buildings and domestic water. These different types of systems are compared, evaluated and critiqued. More specifically, some of the topics covered include current uses of solar energy, active, passive and integrated systems for solar heating and cooling, solar water heating and heat theory. Information is provided in easy-to-understand language with extensive utilization of charts, graphs and drawings for depicting the principles and theories discussed. The text is supplemented with appendices containing technical design information such as metric conversion factors, insulating values of building materials and heat equivalents of fuels for solar back-up. The book also includes a 12-page bibliography with references divided under the following subheadings: solar energy of general interest, general solar energy, solar domestic water heating and swimming pool heating, designing for direct solar radiation and energy conservation.
TEXT OR REFERENCE

Title: SOLAR ENERGY THERMAL PROCESSES
Authors: John A. Duffie and W.A. Beckman
Publisher: John Wiley and Sons, Inc.
Eastern Distribution Center
1 Wiley Drive
Somerset, NJ 08873
Year: 1974
No. of Pages: 386
Cost: $20.25

The purpose of this book is to summarize the state of the art on ways of dealing with the unique problems associated with the engineering design and analysis of solar processes in a manner useful to engineers. The authors restrict their discussion to thermal conversion; i.e., the process by which solar radiation is absorbed by a surface and converted to heat. The emphasis is on solar energy for meeting thermal energy needs for buildings; i.e., heating and cooling. The subject matter covers four major areas: 1) solar radiation, its origin, nature and availability; 2) heat transfer considerations in solar energy; 3) process and system models including collection and storage methods with equations describing their thermal performance and the procedures for solving the systems of component equations; and 4) applications of solar energy including water heating, space heating and air conditioning. Sample problems which illustrate methods of calculation and the kind of results to be expected are included in the text and an appendix. Each chapter contains a reference list of background materials on the topics presented in the chapter. The book is intended mainly for use by engineers and requires familiarization with the principles of calculus.
TEXT OR REFERENCE

Title: SOLAR HEATING DESIGN:
BY THE F-CHART METHOD
Author: William A. Beckman
Publisher: John Wiley and Sons, Inc.
Eastern Distribution Center
1 Wiley Drive
Somerset, NJ 08873
Year: 1977
No. of Pages: 200
Cost: $15.95

"This book, intended for use by engineers, provides a practical method for solving the problem of incorporating solar heating and conventional heating into one system that will supply the entire heating load in the most cost-efficient manner. It considers all parts of the system; a solar collector that heats either liquid or air; a thermal energy storage unit (either a water tank or a pebble bed); and an auxilliary furnace or heater. It describes how to size solar space and water heating systems, discussing how to best utilize the solar collector, storage tank and associated equipment.

"Chapters are nearly complete in themselves, containing introductory material, references to pertinent literature and examples of the major points. They cover:

- description of the common types of solar heating systems which can be designed by the f-chart method;
- the thermal performance of flat-plate solar collectors;
- the effects of collector orientation on the overall performance of solar heating systems;
- methods of estimating the monthly space and domestic water heating loads;
- the f-chart design procedure; and
- how fuel and system cost information can be used to determine the economic optimum design.

"Appendices provide such information as a method for determining the effectiveness of a heat exchanger; monthly average climatic data for estimating long term performance for many North American locations; SI and English units which are useful for performance and economic calculations; and the description of a computer program (called FCHART) that incorporates the concepts described in this book." (Publisher Review)
TEXT OR REFERENCE

Title: SOLAR HOME BOOK
Author: Bruce Anderson
Publisher: Brick House Publishing Company, Inc.
Church Hill
Harrisville, NH 03450
Year: 1976
No. of Pages: 297
Cost: $8.50

The purpose of this publication is to present the principles of solar design in non-technical language that is understandable by the general reader. It is marked with an abundant use of diagrams, drawings and photographs of solar houses, systems and components that effectively illustrate the principles discussed in the text. The book discusses early and recent developments in cooling homes and heating domestic water, basic heat theory, active, passive and integrated systems for solar heating and cooling and do-it-yourself solar projects, such as greenhouses and solar water heating. Appendices provide climatic data including solar angles, clear-day insolation data, solar radiation maps and degree days, and design temperatures; design data including insulating values of materials, heat conduction cost chart, air infiltration cost chart, emittances and absorptances of materials, specific heats and heat capacities of materials and conversion factors and metric/English equivalents; and information and supplies including architects, designers, engineers and manufacturers of solar equipment.
TEXT OR REFERENCE

Title: SOLAR PRIMER ONE
Authors: Quinton M. Bradley and J.F. Carlson
Publisher: SOLARC
P.O. Box 4233
Whittier, CA 90607
Year: 1975
No. of Pages: 101
Cost: $8.75

This book was intended to serve as a guide for designers, architects and laypersons to the application and implementation of solar energy in architecture. The topics covered are the collection of solar energy, the structure of the solar collector, transfer systems and storage of solar energy. In one of the final sections the authors also present the total system for using solar energy in domestic water heating and in heating and cooling buildings. The text is supplemented with housing and solar system diagrams illustrating the various solar storage and collection methods.

Many examples of the use of solar energy in homes and buildings are included. The appendix contains a list of some of the prominent persons in solar energy research and equipment design, a list of manufacturers of solar energy equipment and manufacturers' literature on the type(s) of systems they market.
TEXT OR REFERENCE

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Title: THE SUN:
OUR FUTURE ENERGY SOURCE
Author: David K. McDaniels
Publisher: John Wiley and Sons, Inc.
Eastern Distribution Center
1 Wiley Drive
Somerset, NJ 08873
Year: 1979
No. of Pages: 271
Cost: $12.95

"The principal aim of this text is to help the reader gain an understanding of the ways in which useful energy can be obtained from the incoming solar radiation. Thus, the major portion of this textbook covers topics such as solar radiation, flat-plate collectors, active and passive solar heating systems, solar thermal electric generating schemes and photovoltaic devices. In order to round out the course and provide the requisite background, the first three chapters discuss topics related to the overall energy problem, such as the energy crisis, fossil fuel reserves, and nuclear fission. Some of this introductory material can be readily left out of the course, if desired, without seriously affecting the student's understanding of future developments.

"In keeping with introductory nature of the course, the presentation has been kept as nonmathematical as possible. The emphasis is entirely upon developing a qualitative understanding of the subject. Numerical examples are occasionally worked out to illustrate the principles involved; however, students are not expected to be able to work out detailed calculations themselves. The problems at the end of each chapter were chosen to span a large range of difficulty. Some of the multiple-choice questions are exceedingly easy, included only to check that the reader is aware of the most basic facts.

"The system of units used in this book is the MKS system, which is essentially the SI system of units, with certain modifications. In this metric system the basic units of length, mass, and time are the meter, kilogram, and second. The corresponding metric unit of energy is the joule. Occasionally, English units have been used when it was felt that current practice demanded their usage."
(Excerpt from Author's Preface)
TEXT OR REFERENCE

Title: UNDERSTANDING SOLAR ENERGY SYSTEMS
Authors: Laurie Keaton and Everett Edington
Publisher: Wisconsin Vocational Studies Center
University of Wisconsin - Madison
964 Educational Sciences Building
1025 W. Johnson Street
Madison, WI 53706
Year: 1978
No. of Pages: 127
Cost: $7.00

This document is an instructional package designed to provide persons trained in existing skill areas with a basic understanding of solar energy systems. It is suitable for use in post-high school technical education and adult education programs. It can be used in both pre-service and in-service training in the installation of solar energy systems. Unit I describes some of the characteristics of solar radiation and why solar energy should be developed as an energy source. Unit II demonstrates the importance of the position of the sun in relation to the earth for making use of the sun's energy. The principle governing the operation of solar energy systems and the system components are presented in Unit III. Unit IV emphasizes the types of collectors and their function as a component in a solar energy system. Unit V presents similar information on the storage component of a solar system. In unit VI available methods for transporting the thermal energy are discussed. The final unit describes some representative solar energy systems. Accompanying the instructional package are transparency masters which illustrate the principles discussed.
TEXT OR REFERENCE

Title: PHASE 1 (SOLAR) JOB RELATED TRAINING
Author: Lennox Industries, Inc.
Publisher: Lennox Education Products
P.O. Box 400450
Dallas, TX 75240
Year: 1979
No. of Pages: 314
Cost: $13.00

This manual is the solar component of the Lennox heating/air conditioning training program. All manuals are designed to present technical information in a format that makes it easy to comprehend (eighth and ninth grade reading level). Theory is kept at a minimum while practical knowledge is emphasized. Lennox offers a multimedia line of educational materials, including overhead slides, films, videotapes, trainers and commercial equipment, that are compatible with the manuals. Phase 1 (SA) is designed to acquaint students with solar system design and installation. It provides information on the following subjects: solar systems—past and present, the sun, solar energy collection, Lennox space heat/domestic hot water systems, components, operating modes, controls, equipment selection, data economics, installation and Lennox domestic hot water system. The manual is illustrated throughout with drawings, photographs, graphs, diagrams, tables and charts.
TRAINING MANUAL

Title: REVERE SUN-PRIDE SYSTEM
INSTALLATION MANUAL
Author: Revere Solar and Architectural Products, Inc.
Publisher: Revere Solar and Architectural Products, Inc.
Rome, NY 13440
(315)338-2401
Year: Undated
No. of Pages: 31
Cost: No charge with Equipment Purchase

This manual provides the installation procedures for the Revere Sun-Pride domestic water solar heating system. The first section describes all of the system components and their functions. The second section deals with the installation of the system. Information is provided for determining the orientation, slope and location of solar collectors; the necessary installation materials; the collector mounting procedure; pipe sizing, soldering, filling and testing the system; and insulation. The final section provides maintenance and service information. Maintenance procedures are outlined, along with the information on glass removal or replacement and repairing leaks. Also included is a troubleshooting chart.
TRAINING MANUAL

Title: SOLAR ENERGY EQUIPMENT TECHNICIAN TRAINING PROJECT

Project Director: George Samson

Address: Ocean County Vocational-Technical Schools
350 Chambersbridge
Bricktown, NJ 08723

Year: 1979

The Ocean County Vocational-Technical School conducted a five-day training project for plumbers and air conditioning/refrigeration mechanics on solar energy equipment installation. Skill requirements for participation in the workshop were pipe measuring, soldering and mechanical fabrication. The Project included classroom instruction and hands-on training. A training manual was assembled for use during the training project. The manual is divided into the following sections: 1) introductory materials, 2) collectors, 3) accessories and 4) installation. The introductory materials consist of general information on "solar collectors and the collection process," "types of solar systems with specific tips on installation," "mounting collectors," "insulation and solar heat" and a personal account by someone who installed his own solar system. The remaining sections contain brochures, spec sheets, product information bulletins, installation manuals, etc., produced by manufacturers of solar equipment. Represented among the manufacturers are Daystar, Sunworks, Revere, Heliotherm, PPG Industries, Olin Brass, Solaron, Bell and Gossett, Pho Sigma, DuPont, Ranco A.O. Smith and Heliotrope General.

TRAINING MANUAL

Title: SOLAR HEATING AND COOLING OF RESIDENTIAL BUILDINGS: DESIGN OF SYSTEMS

Author: Solar Energy Applications Laboratory

Publisher: Government Printing Office
Washington, DC 20402

Stock No.: 003-011-00084-4

Year: 1977

No. of Pages: 575

Cost: $8.25

This book was designed to serve as a training manual for designing solar heating and cooling systems. It was developed for use by practitioners in the home building industry. This and a companion document, *Sizing, Installation and Operation of Systems*, provide training for home designers and builders in the fundamentals of solar hydronic and air systems for space heating and cooling and domestic hot water heating. The modular format of the training courses provides flexibility in the organization and presentation of the material, particularly with respect to the time frame of the course. The first module presents an overview of the training course and a synopsis of each module's content. The additional 22 modules cover the following topics: general description of solar heating and cooling systems; solar radiation information for design purposes; system design guidelines; heating and cooling load analyses; simplified design calculations, detailed design methods; economic considerations; energy conservation trade-offs; detailed design calculations; collectors; storage systems; laboratory; computer-aided f-chart calculations; system controls; selection of subsystem components; solar cooling systems; automated design techniques; service hot water systems; design case study; structural, mechanical and scheduling considerations; future prospects for solar heating and cooling systems; and buyer's guide.

TRAINING MANUAL

Title: SOLAR HEATING AND COOLING OF RESIDENTIAL BUILDINGS: SIZING, INSTALLATION AND OPERATION OF SYSTEMS

Author: Solar Energy Applications Laboratory

Publisher: U.S. Government Printing Office
Washington, DC 20402

Stock No.: 003-011-00085-2

Year: 1977

No. of Pages: 402

Cost: $7.00

This book was designed to serve as a training manual in sizing, installing and operating solar heating and cooling systems for residential buildings. It was intended for use by practitioners in the home building industry. This and a companion document, *Design of Systems for Solar Heating and Cooling of Residential Buildings*, provide training for home designers and builders in the fundamentals of solar hydronic and air systems for space heating and cooling and domestic hot water heating. The modular format of the training course provides flexibility in the organization and presentation of the material particularly with respect to the time frame of the course. This book contains 22 modules, each with its own objectives, introduction and summary. Module 1 provides an overview of the energy problem, the sources of energy and their development status and prospect for future use. The organization of the course and a synopsis of the modules is provided in Module 2. The remaining modules present information on the following: solar radiation; fluid heating solar collectors; thermal storage subsystems; service hot water systems; solar heating systems; solar space cooling systems; solar heating and cooling systems; solar system controls, operations laboratory; heating load calculations; solar system sizing; system economics; solar system sizing calculations by trainees; cost-effectiveness of energy conservation; retrofit considerations; scheduling of solar installations; constraints and incentives; buyer's guide and future prospects for solar heating and cooling systems.

TRAINING MANUAL

Title: SOLAR HEATING SYSTEMS DESIGN MANUAL
Author: Bell and Gossett ITT
Publisher: Bell and Gossett ITT
Training and Education Department
Fluid Handling Division
8200 N. Austin Avenue
Morton Grove, IL 60053
Year: 1976
No. of Pages: 130
Cost: $3.00

This manual was produced in an effort to share the results of ITT's research of an operating hydronic solar heating/cooling system. It was intended to assist engineers, contractors, architects, students and builders involved with solar hydronic heating installations. Presented in the first chapter are the comparative effects on solar design of insulation and building location. Chapter 2 provides a brief discussion of the nature of solar radiation followed by numerous charts and tables which illustrate or project the availability of solar energy. Described in Chapter 3 are low concentration solar collectors which do not require tracking, specifically the flat plate collectors. The chapter examines variables and conditions which aid the system designer in selecting an appropriate collector and integrating the collector into overall system design. Presented in Chapter 4 is information about the operation of the complete solar heating system and the three interconnected basic subsystems of which it is composed: the collector system, the storage system and the final terminal system, including the domestic hot water system. Chapter 6 provides several design examples of solar systems. Chapter 7 describes the solar drive heating and cooling system installed at ITT Fluid Handling Division's Bell and Gossett training facility in Morton Grove, Illinois. References are provided throughout the text for sources of further information.

TRAINING MANUAL

Title: SOLARON CORPORATION SOLAR ENERGY SYSTEMS
Author: Solaron Corporation
Publisher: Solaron Corporation
300 Galleria Tower
720 S. Colorado Boulevard
Denver, CO 80222
(303)759-0101
Year: 1978
Cost: Free to equipment purchasers.

This document contains five manuals dealing with the installation and engineering of Solaron components. The first is an application engineering manual which is designed to furnish the necessary information for architects, engineers and other design specialists to correctly design solar heating systems using Solaron solar heating equipment. The manual describes the Solaron solar heating system, provides performance data for the components and the complete system and describes the ducting and mechanical requirements for the system. Contained in the second manual are installation procedures for the Series 3000 collector. The necessary dimensional and mounting information is provided along with descriptions of the necessary hardware. The third manual contains installation procedures for the Series AUO400 and AUO500 air handler. This manual provides information on required mounting, dimensions, the control panel, sensors, system start-up, domestic water coil capacities and other information necessary for installation of the air handler. The fourth manual provides installation procedures for the residential heat storage unit. It is a general guide for sizing and building the heat storage unit for a Solaron solar heating system. The fifth manual contains similar information for a commercial heat storage unit. All manuals provide numerous detailed drawings and diagrams for illustration of the procedures and components described.

TRAINING MANUAL

Title: TRAINING COURSES FOR PRACTITIONERS TO DESIGN, INSTALL AND OPERATE SOLAR HEATING AND COOLING SYSTEMS FOR RESIDENTIAL BUILDINGS
Authors: S. Karaki, D.S. Ward and C.B. Winn
Publisher: Solar Energy Applications Laboratory
Colorado State University
Fort Collins, CO 80523
Year: 1976
No. of Pages: 14

This is a paper prepared for the "Sharing the Sun 76" conference in Winnipeg, Manitoba, August 15-20, 1976. It presents an overview of the two training courses on the design and installation of solar heating and cooling systems in residential buildings developed at Colorado State University. The paper provides information on goals for the training courses, descriptions of each course and the training manuals used. Course descriptions include the course objectives, curriculum and outline and a listing of the standards and needs of designers and installers.

TRAINING MANUAL

Title: UTILIZING A NATURAL RESOURCE
Author: LOF Solar Energy Systems
Publisher: Marketing Manager
LOF Solar Energy Systems
1701 E. Broadway
Toledo, OH 43605
Year: Undated
Cost: No charge with equipment purchase.

This publication was intended for use as a training and marketing manual for the solar energy system, Sun Panel, manufactured by LOF. It is divided into the following sections: general information, technical information, Sun Panel collector and system, pricing, warranties, installation procedures, marketing information and advertising promotion. The general information section consists of brochures and fact sheets on the Sun Panel solar system. Contained within the section on technical information are specifications information, product data, technical bulletins and f-chart computer examples. A set of installation procedures to use as a guide in mounting Sun Panel solar collectors is also included. The remaining sections are self-explanatory by their titles.

Note: The section on Sun Panel collector and systems was not included in the manual; and, therefore, no comments can be made concerning it.

TRAINING MANUAL

Title: STANDARD 93-77: METHODS OF TESTING TO DETERMINE THE THERMAL PERFORMANCE OF SOLAR COLLECTORS
Author: The American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. Standard 93-77 Project Committee
Publisher: ASHRAE Publications Sales Department 345 E. 47th Street New York, NY 10017
Year: 1978
No. of Pages: 50
Cost: $8.00 (nonmembers)

"The purpose of this standard is to provide test methods for determining the thermal performance of solar energy collector modules (herinafter called solar collectors) which heat fluids for use in thermal systems. This standard applies to non-concentrating and concentrating solar collectors in which a fluid enters the collector through a single inlet and leaves the collector through a single outlet. Collectors containing more than one inlet and more than one outlet may be tested according to this standard provided that the external piping or ducting can be connected so as to provide effectively a single inlet and a single outlet. The heat transfer fluid (hereinafter called the transfer fluid) may be either a liquid or a gas but not a mixture of the two phases. This standard contains methods for conducting tests outdoors under simulated solar irradiation. This standard provides test methods and calculation procedures for determining steady state and quasi-steady state thermal performance, time, and angular response characteristics of solar collectors. This standard is not applicable to those collectors in which the thermal storage unit is an integral part of the collector to such an extent that the collection process and the storage process cannot be separated for the purpose of making measurements of these two processes."
(The above represents the Purpose and Scope contained within Standard 93-77.)
CODES AND STANDARDS

Title: STANDARD 94-77: METHODS OF TESTING THERMAL STORAGE DEVICES BASED ON THERMAL PERFORMANCE
Author: The American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. Standard 94-77 Project Committee
Publisher: ASHRAE Publications Sales Department 345 E. 47th Street New York, NY 10017
Year: 1977
No. of Pages: 22
Cost: $6.00 (nonmembers)

"The purpose of this standard is to provide a standard procedure for determining thermal performance of thermal storage devices used in heating, air conditioning and service hot water systems. This standard applied to sensible heat and latent heat-type thermal energy storage devices in which a transfer fluid enters the device through a single inlet and leaves the device through a single outlet. Storage devices having more than one inlet and/or outlet may be tested according to this standard, but each flow configuration involving a single inlet and single outlet must be tested separately. This standard is not applicable to those configurations in which there is simultaneous flow into the storage device through more than one inlet and/or simultaneous flow out of the storage device through more than one outlet. The transfer fluid can be either a gas or liquid or a mixture of the two. This standard does not include factors relating to cost, life, reliability, or the consideration of requirements for interfacing with specific heating and cooling system. The test procedure and equipment outlined in this standard are most easily adaptable to devices used to store thermal energy on the order of 10^{10} J (10^7 Btu) or less."
(The above represents the Purpose and Scope contained within Standard 94-77.)
CODES AND STANDARDS

Title: SOLAR ENERGY PROCESSES: SYSTEMS, PART 1 AND 2
Producer: Charles Casey
Available From: Library Filmstrip Center 3033 Aloma Wichita, KS 67211
Year: 1979
Length: 118 frames, 34 min.
Cost: $52.00

Solar Energy Processes: Systems constitutes the final two filmstrips (with accompanying taped scripts) in a series on solar energy. The first two filmstrips deal with the principles and theories of solar energy, while these present more technical information on the operation and design of solar collectors and storage units. All four filmstrips are appropriate for use at the secondary and post-secondary level. *Solar Energy Processes: Systems* effectively presents material on 1) various types of collectors (flat plate, semi-imaging, and true imaging), such as absorber surface properties, tubing dispositions, insulative materials and different methods for tracking solar radiation and 2) various solar storage systems (thermal, chemical and mechanical), such as how they operate as an integral part of the system, types of mixtures used, storage considerations, design variables and storage mode.
AUDIOVISUAL

Title: SOLAR ENERGY PROCESSES: THEORY, PART 1 AND 2
Producer: Charles Casey
Available From: Library Filmstrip Center 3033 Aloma Wichita, KS 67211
Year: 1979
Length: 87 frames, 30:03 min.
Cost: $52.00

Solar Energy Processes: Theory, comprised of 2 filmstrips with accompanying taped scripts, is appropriate for use at the secondary and post-secondary levels. These two filmstrips are the first of a series on solar energy processes and present information on the principles and theories of solar energy. Two additional filmstrips, titled *Solar Energy Processes: Systems*, Part 1 and 2, provide more technical information on the operation and design of solar collectors and storage systems. The filmstrips on theory effectively illustrate material on the following: the development of scientific thinking on the properties of the sun, its movement, the laws of motion and gravity, solar radiation, absorption and a brief introduction into solar collectors and how they function.
AUDIOVISUAL

CURRICULUM MATERIALS

Title: DEVELOPMENT OF TRAINING CURRICULUM IN SOLAR HEATING AND COOLING AT THE TECHNICAL LEVEL
Authors: Dick Downen, C. Walter Troutman, Carl J. Kuhnle, Lonnie D. Freeman
Publisher: Texas State Technical Institute
James Connally Campus
Waco, TX 76705
Year: 1977
No. of Pages: 214

This document is the final report of a project conducted by the Texas State Technical Institute. The objectives of the project were to develop a curriculum for training solar technicians, to design the various components of a training program, to facilitate implementation of the training program and to validate the curriculum through seminars, workshops, short courses and public information releases. The appendices to the document include the results of the project.These provide a list of advisory committee members, a solar energy technology task inventory and results, a solar technology curriculum and a six-quarter program, program syllabi, a recommended list of training unit titles, an annotated bibliography, solar training materials, training facility and faculty information, and short courses in solar training. The document serves as a curriculum resource guide and provides much useful information for the development of a solar technology program.
CURRICULUM GUIDE

Title: HANDBOOK OF ENERGY LESSON PLANS, COLLEGE LEVEL
Author: The Solar-Ed Corporation
Available From: Library Filmstrip Center
3033 Aloma
Wichita, KS 67211
Year: 1977
Cost: $3.00

This document contains college-level lesson plans on eight topics relating to solar energy: Newton's law of cooling, how insulating materials affect heat loss, how to measure the specific heat of a thermal fluid, properties of thermal fluids, how the specific heat of a thermal fluid is affected by diluting it with water, testing absorbing surfaces and coatings, using an insolation meter to measure incident energy during any time period and a graphical technique for energy averaging. The lesson plans are designed for non-science majors and include basic principles of solar collector operation and design. They are complete with instructions for building equipment from available materials.
CURRICULUM GUIDE

Title: HANDBOOK OF ENERGY LESSON PLANS, HIGH SCHOOL LEVEL
Author: The Solar-Ed Corporation
Available From: Library Filmstrip Center
3033 Aloma
Wichita, KS 67211
Year: 1977
Cost: $3.00

This document contains high-school level lesson plans and twelve topics relating to solar energy: places in the home where heat loss occurs, convection of heat from a hot object, measuring the power output of a solar cell, solar glazing materials, an air-heated solar collector, measuring a student's horsepower rating, determining the operating efficiency of a solar collector, the method for calculating the collector efficiency for focusing collectors and measuring air pollution with a light meter. Mathematics and physics are incorporated into the lessons along with exercises and experiments which illustrate the principles under study.
CURRICULUM GUIDE

Title: RESIDENTIAL SOLAR APPLICATION OUTLINE I (SA)
Author: Lennox Industries, Inc.
Publisher: Lennox Education Products
P.O. Box 400450
Dallas, TX 75240
Year: Undated
No. of Pages: 41
Cost: $5.00

This document is the curriculum guide developed by Lennox to accompany their training materials for residential solar applications. Training is divided into twelve segments: introduction, solar system history, the solar system, the sun, the collector, system-electrical, solar system design engineering, equipment selection, solar system investigations, economic analysis, domestic hot water and computer programs. Each segment contains objectives for the training, reference materials, visual aids, the method of conducting training and an outline for that segment. Also included are illustrations of overhead transparencies that can be used in teaching the material.
CURRICULUM GUIDE

Title: SOLAR ENERGY PROJECT TEACHER'S GUIDE
Author: U.S. Depart of Energy
Assistant Secretary for Conservation and Solar Application
Market Development and Training Program
Publisher: U.S. Government Printing Office
Washington, DC 20402
Stock No.: 061-000-00234-1
Year: 1979
No. of Pages: 35
Cost: $2.50

The Solar Energy Education Project was designed to educate society in the proper utilization of the sun as an energy source. The teacher's guide was developed by secondary school teachers and contains numerous educational activities on solar energy for grades 7-12. The activities are designed to be incorporated into existing curricula.

This document is part of a Solar Energy Curriculum which consists of seven packets: a teacher's guide and support material (1),

classroom activities (5) and a solar energy test (1). Contained within the teacher's guide are the following sections: the activity format, activity list with descriptions, instructional strategies, description of supporting materials, role of solar energy text and project overview. The support materials contained within this packet are intended to supplement the activities and include hardware useful in serving the needs of the classroom, multi-disciplinary extensions which describe ways to apply the concepts, methods and materials of many curricular fields to the study of solar energy, and references and resources for solar energy courses.
CURRICULUM GUIDE

Title: SOLAR ENERGY TASK FORCE REPORT ON EDUCATION AND TRAINING
Authors: Solar Energy Research Institute and Solar Energy Task Force
Publisher: Department of Energy
Education Programs Division
1000 Independence Avenue, SW
Washington, DC
(202)252-6482 or 252-5544
Year: 1978
No. of Pages: 49
Cost: No charge

"The Solar Energy Task Force Report summarizes data, information and discussions stemming from the Task Force Workshop of September 12-13, 1978. The Task Force members, leaders in the field involved with various aspects of solar technical training programs, were brought together to discuss the problems of training issues from the perspectives of education, labor, and business.

"The Task Force mission focuses on solar space and water heating applications. The report is intended to fill a need for curriculum and course development and direction for technical training programs, especially in vocational/technical schools and community/junior colleges. The report addresses itself primarily to the questions of curriculum suggestions [Sample curricula and programs are presented.]; jobs, tasks and skills for which training is needed [Job skills are defined for a solar equipment sales person, designer, installer, electrician, supervisor and service technician.]; and equipment recommendations necessary in establishing a solar training center [Some example equipment inventories are provided in an appendix.]. As well, the fundamental issues centering on the questions of whether or not to offer a solar program are addressed." (Modified foreword by Kevin O'Connor)
CURRICULUM GUIDE

Title: SOLAR ENERGY TECHNOLOGY: SUPPLEMENTARY CURRICULUM MATERIALS
Compiled by: CONSERVA, Inc.
Available From: East Central Curriculum Coordination Center
100 North 1st Street
Springfield, IL 62777
Year: 1979

This document was compiled and bound by CONSERVA, Inc. and consists of curriculum outlines, course descriptions and course objectives used in various post-secondary vocational education programs across the country. Also included is information on several workshops that have been conducted for the purpose of training participants in installation and maintenance skills. The following is a list of community colleges, universities and technical institutes represented in the document:

- Community College of Denver — Red Rocks Campus
- Clark County Community College
- Scott Community College
- Navarro College
- Southwestern Technical Institute
- Bristol Community College
- Red Wing Area Vocational Technical Institute
- Western Iowa Technical Community College
- San Jose City College
- Massasoit Community College
- North Central Technical Institute
- Western Wisconsin Technical Institute
- New Castle Vocational Technical School District, Energy Conservation and Solar Application Training Center — materials developed by the Colorado State University's Solar Energy Application Laboratory under Dr. Susumi Karaki
- New Mexico State University
- Stockton State College
- Colorado State University, The Solar Energy Application Laboratory
- Ocean County Vocational Technical Schools
- Wisconsin Board of Vocational, Technical, and Adult Education
- Glassboro State College
- Texas State Technical Institute

CURRICULUM GUIDE

Title: SOLAR ENERGY EDUCATION BIBLIOGRAPHY
Author: Center for Renewable Resources
Publisher: Center for Renewable Resources
1028 Connecticut Avenue NW
Washington, DC 20036
Year: 1979
No. of Pages: 39
Cost: $2.50

This document provides a comprehensive, annotated listing of solar publications and audiovisual materials for use as education materials. Only those materials dealing specifically with renewable resources were selected for inclusion. Also, books were chosen on the basis of whether they lend themselves readily to classroom use. The publications are categorized by grade level: elementary, preschool to sixth grade; secondary, seventh to twelfth grades; and college, two-year, four-year, vocational-technical and adult programs. Publications are further categorized according to the type of energy source they deal with; i.e., solar, wind, water, biomass or renewable resources in general. The audio-visual section includes distributor names and addresses and rental and purchase prices for films, video-cassettes, slideshows and filmstrips.
BIBLIOGRAPHY

Title: SOLAR ENERGY TECHNOLOGY: EQUIPMENT/TRAINING AIDS/ AUDIOVISUALS
Compiled by: CONSERVA, Inc.
Available From: East Central Curriculum Coordination Center
100 North 1st Street
Springfield, IL 62777
Year: 1979

This document contains brochures, catalogs, fact sheets on audio-visuals, training aids and equipment for solar energy technology programs. This information was compiled and bound by CONSERVA, Inc. and includes the following:

- "Films/Slides/Videotapes" published by the National Solar Heating and Cooling Information Center
- Modutek, Inc. Solar Skills System information sheet
- "Stockton State College's energy house" reprinted from *The Physics Teacher*, October 1976
- "Conservation and Solar Energy Curriculum Planning Guide and Catalog — The Kwasnoski Solar-Ed Energy Modules" by the Solar-Ed Corporation
- "1979 Energy Projects and Experiments" by the Megateck Corporation
- "Guide to Visual Aids for Solar Energy" published by the Mid-American Solar Energy Complex
- Lennox catalog of training materials and equipment, specification sheets and brochures on commercial and education equipment

CATALOG

Title: ILLINOIS SOLAR ENERGY DIRECTORY
Authors: Bruce D. Green and David Z. Pogany
Publisher: Illinois Institute of Natural Resources
385 West Adams Street, Room 300
Springfield, IL 62706
Year: 1978
No. of Pages: 114
Cost: No charge

The purpose of this publication is to provide pertinent information concerning the solar energy industry in Illinois to builders, developers, manufacturers, consumers and the general public. The directory contains name and address listings of Illinois solar equipment distributors and installers, component manufacturers, and solar energy consultants in building and system design and engineering. Also provided are nationwide consultants, manufacturers and distributors. Additional information provided in the directory includes consumer protection tips, selected references, a list of alternative energy periodicals, societies and organizations, and known solar applications in Illinois.

DIRECTORY

Title: NATIONAL SOLAR ENERGY EDUCATION DIRECTORY, First Edition
Authors: George Corcoleotes, Katherine Kramer, Kevin O'Connor and Jo Ann Silversmith
Publisher: U.S. Government Printing Office
Washington, DC 20402
Stock No.: 061-000-00210-3
Year: 1979
No. of Pages: 279
Cost: $4.75

This publication was meant to serve as a directory of post-secondary educational institutions offering programs or courses in solar energy. It provides a listing of institutions alphabetically by institution type within state. Within each institution cited are listings of solar-related programs and curricula (where they exist) followed by an alphabetic listing of solar-related courses by course title. The directory includes other information such as an address and phone number for each institution cited; degree information, contact person and field of students taking the offering for each program and curriculum cited; and instructor name, course number, departments, number of credits, student level, duration of the course, contact hours and topics covered for each course listed. This document contains entries for approximately 700 institutions.

DIRECTORY

Title: THE ADVENT OF SOLAR ENERGY, IMPLICATIONS FOR VOCATIONAL EDUCATION IN ILLINOIS
Authors: Sherry Ann Rubinstein and James G. Ramsay
Publisher: Illinois State Board of Education
Department of Adult, Vocational and Technical Education
Research and Development Section
100 North 1st Street
Springfield, IL 62777
Year: 1977
No. of Pages: 78
Cost: No charge

"The major purpose of the study was to describe the types and numbers of jobs that may be created or influenced by development of the solar energy industry and to determine the potential effect on vocational training needs.

"The presentation of the results of the study begins with a discussion of the range of possible solar energy applications and a discussion of priority applications for the state of Illinois (Chapter 2). Chapter 3 presents a set of high-priority actions that might be taken by State-level planners to facilitate the expansion of these solar applications.

"The report proceeds with a review of manpower studies and projections for the solar industry (Chapter 4) and a discussion of the solar-related occupations for which training needs can be identified (Chapter 5).

"The report concludes with a discussion of issues related to solar education and training (Chapter 6) and a description of current efforts towards designing solar-related curricula (Chapter 7)." (Taken from the Authors' Introduction)

TECHNICAL REPORT

REFERENCES

Forgione, Pascal D., Jr. and A.L. Kopp. *Curriculum Development Needs for Vocational Education: New and Changing Occupational Areas.* Columbus, OH: The Ohio State University, The National Center for Research in Vocational Education, 1979.

Johnson County Community College, Office of Institutional Research. "Employer Manpower Needs and Job Entry Requirements for Biomedical Equipment Technician." In *Special Package of Instructional Resources for Biomedical Equipment Technology.* Columbus, OH: The Ohio State University, The National Center for Research in Vocational Education, 1978.

Meleen, Paulette S., and others. *Planning for Vocational Education: New and Emerging Occupations.* Belmont, MA: Contract Research Corporation, 1976.

Nelson, Orville. "Emerging occupations." *The Wisconsin Vocational Educator*, 1978, *4*, pp. 1-3.

Rubinstein, S.A., and J.G. Ramsay. *The Advent of Solar Energy: Implications for Vocational Education in Illinois.* Amherst, MA: National Evaluation Systems, Inc., 1977.

Solar Energy Task Force. *Solar Energy Task Force Report on Education and Training.* Golden, CO: The Solar Energy Research Institute, 1978.

Spetz, Sally H., W.D. Heath, and D.S. Katz. *Current and Future Employment Opportunities in New and Emerging Occupations Within Illinois.* Raleigh, NC: CONSERVA, Inc., 1978. (Sponsored by the Illinois State Board of Education.)

U.S. Department of Energy, Energy Information Administration. *Annual Report to Congress, Volume II.* Washington, DC: Author, 1977.

APPENDICES

APPENDIX A

SCHOOLS CONTACTED WHICH OFFER COURSEWORK IN SOLAR ENERGY TECHNOLOGY

CALIFORNIA

San Jose City College
2100 Moorpark Avenue
San Jose, CA 95128

COLORADO

Solar Energy Applications Laboratory
Colorado State University
Fort Collins, CO 80523

Community College of Denver at Red Rocks
12600 W. Sixth Avenue
Golden, CO 80401

DELAWARE

Energy Conservation and Solar Application Training Center
New Castle County Vocational Technical School District
1703 School Lane
Wilmingtoin, DE 19804

IOWA

Scott Community College
Belmont Road
Bettendorf, IA 52722

Western Iowa Tech Community College
4647 Stone Avenue
P.O. Box 265
Sioux City IA 51102

MASSACHUSETTS

Massasoit Community College
290 Thatcher Street
Brockton, MA 02402

Bristol Community College
777 Elsbree Street
Fall River, MA 02720

MICHIGAN

Lansing Community College
P.O. Box 40010
Lansing, MI 48914

MINNESOTA

Red Wing Area Vocational Technical Institute
Highway 58 at Pioneer Road
Red Wing, MN 55066

NEVADA

Clark County Community College
3200 E. Cheyenne Avenue
North Las Vegas, NV 89030

NEW JERSEY

Ocean County Vocational Technical Schools
350 Chambers Bridge Road
Bricktown, NJ 08723

Glassboro State College
Glassboro, NJ 08028

Stockton State College
Pomona, NJ 08240

NEW MEXICO

New Mexico State University
P.O. Box 3450
Las Cruces, NM 88003

NORTH CAROLINA

Southwestern Technical Institute
Box 95
Sylva, NC 28779

TEXAS

Navarro College
Highway 31 West
Corsicana, TX 75110

Texas State Technical Institute
James Connally Campus
Waco, TX 76705

WASHINGTON

Tacoma Community College
5900 South 12th Street
Tacoma, WA 98465

WISCONSIN

Western Wisconsin Technical Institute
La Crosse, WI 54601

North Central Technical Institute
Wausau, WI 54401

APPENDIX B

INDIVIDUALS INDICATING AN INTEREST IN CONSULTING

Leon Calovita
New Jersey State Department of Education
225 West State Street
Trenton, NJ 08625
(609)292-6563

Pat Enz
Red Wing AVTI
Highway 58 at Pioneer Road
Red Wing, MN 55066

Mel Forsling
Western Iowa Tech Community College
4647 Stone Avenue
P.O. Box 265
Sioux City, IA
(712)276-0830

Carmen Gioia
Scott Community College
Belmont Road
Bettendorf, IA 52722
(319)359-7531

Craig Hilton
Community College of Denver at Red Rocks
12600 W. Sixth Avenue
Golden, CO 80401
(303)989-1611

John Kwasnoski
The Solar-Ed Corp.
28 Burnet Street
Springfield, MA
(413)782-3111

Anthony Mercurio
Bristol Community College
777 Elsbree Street
Fall River, MA 02720
(617)678-2811

Arthur Meyer
Navarro College
Corsicana, TX 75110
(214)874-6501

Lorraine Stephans
Tacoma Community College
5000 South 12th Street
Tacoma, WA 98465
(206)756-5024

Sterling Stewart
Western Iowa Tech Community College
4647 Stone Avenue
P.O. Box 265
Sioux City, IA
(712)276-0380

APPENDIX C

RELATED AGENCIES/ORGANIZATIONS

NATIONAL AGENCIES/ORGANIZATIONS

American Society of Heating, Refrigeration and
Air Conditioning Engineers, Inc.
345 E. 47th Street
New York, NY 10017

American Solar Energy Association
Suite 931
1346 Connecticut Avenue
Washington, DC 20036

Center for Renewable Resources
1028 Connecticut Avenue N.W.
Washington, DC 20036

International Solar Energy Society
American Section
P.O. Box 1416
U.S. Highway 190 West
Killeen, TX 76541
(817)526-1300

Mid-American Solar Energy Complex
1256 Trapp Road
Eagan, MN 55121
(612)452-5300

National Association of Solar Contractors
c/o Leu Boyd
Solar Solutions, Inc.
P.O. Box 197
Sudbury, MA 01776

National Solar Heating and Cooling Information Center
P.O. Box 1607
Rockville, MD 20850
(800)523-2929

Solar Energy Construction Association
404 West Campbell Avenue
P.O. Box 8000
Roanoke, VA 24014

Solar Energy Industries Association
1001 Connecticut Avenue, N.W.
Suite 632
Washington, DC 20036

Solar Energy Institute of America
P.O. Box 9852
Washington, DC 20005

Solar Energy Research and Education Foundation
1001 Connecticut Avenue, N.W.
Suite 800
Washington, DC 20036

The Solar Energy Research Institute
1536 Cole Boulevard
Golden, CO 80401

The Solar Solution, Inc.
6802 Walker Mill Road, S.E.
Washington, DC 20027

ILLINOIS AGENCIES/ORGANIZATIONS

Central IL Solar Energy Society
Martin Mavis
One Ramblewood Drive
Rochester, IL 62563

Fermilab Solar Club
John O'Meara, President
Fermilab
Batavia, IL 60510

Illinois Solar Association
c/o Solar Store Foundation
P.O. Box 841
Peoria, IL 61652

Northern IL Solar Energy Society
J.A. Hartley, Secretary
P.O. Box 352
Argonne, IL 60439

Shawnee Solar Project
211½ W. Main
Carbondale, IL 62901

Solar Resource Advisory Panel
Jill Kunka, Coordinator
Institute of Natural Resources
325 W. Adams Street, Room 300
Springfield, IL 62706

APPENDIX D
TASK LISTINGS AND JOB COMPETENCIES

D.1 Solar Jobs, Associated Tasks and Skills

D.2 Job Functions

D.3 Job Standards and Needs

D.4 Tabulation of Task Inventory

APPENDIX D.1

Solar Jobs, Associated Tasks and Skills

Solar Energy Task Force. *Solar Energy Task Force Report on Education and Training*. Golden, CO: The Solar Energy Research Institute, 1978.

A. **Sales.** Solar sales personnel must be well-versed in the various applications of solar and be able to:

1. *Describe Different Systems.* The sales person should be conversant with all types of solar heating and cooling systems, including domestic hot water applications. The sales person must also understand conventional HVAC systems and how solar systems will tie in with various conventional types in the case of solar retrofits; or be able to match solar systems with HVAC systems in new applications.
2. *Show the Finished Product.* The sales person must be able to explain and show the details of the finished system, including how it will look on the building, where the various components will be placed and any other structural impacts on the building which the system may have.
3. *Explain Performance.* The sales person must be able to describe the expected performance of the solar system: how it will operate with the conventional system and how much energy, under average conditions, the system should be able to deliver to the building. The sales person must have the ability to demonstrate energy saving expectations of the particular system under consideration.
4. *Recommend a Particular System.* The sales person must be sufficiently familiar with solar componentry to be able to recommend an optimum system for each application. Knowledge of which components work best together and know-how to design and size components properly to insure successful system operation will also be necessary.
5. *Explain System Operation and Maintenance.* The sales person must be intimately familiar with the various modes of operation so that each mode can be explained clearly. An ability must be demonstrated to detail each mode of operation and show how the controls will activate the various modes, including which pumps, motors and blowers will be active in each mode, and the open/close positions of various valves and dampers with each system contingincy. The sales person must know and communicate the maintenance operations and intervals which will be necessary for each particular system installation.
6. *Explain Impact on Comfort.* The sales person must be able to explain any possible effects on comfort level which the solar system might have. Potential impacts on humidity, time/temperature fluctuations and noise levels must be noted where necessary.
7. *Estimate System Costs.* A primary interest to the customer will be the additional cost of a solar system for a retrofit situation or the cost above the conventional system for a new installation. The sales person must know how to estimate costs of components, labor, energy usage, etc. An estimate of system savings on the energy bill must be made, although it was suggested that emphasis should not be placed on investment payback periods. The sales person must have knowledge of local, state and federal solar incentive programs for tax credits, rebates, etc. As well, a knowledge of local building codes and insurance practices relative to solar construction will be necessary.

B. **System Designer.** The system designer is responsible for laying out the details of the solar system. As such, the designer will be the main interface person between the project architect and mechanical engineer. The system designer will be responsible for providing the intricate details which will insure successful system installation and interconnection with the conventional HVAC system. Therefore, a need exists to have detailed operational knowledge of conventional and solar systems. The system designer must be able to:

1. *Select the Proper System Type.* From among the myriad of solar systems available, the system designer must be able to select the proper type of system which will be appropriate for: a) meeting building's heating/cooling load requirements; b) geographic location, c) integration into the architectural design, d) complying with the maximum structural stress of the area in which the system in integrated and e) all local code requirements.
2. *Select Optimum System Size.* While larger systems properly sized with storage will yield more energy to the consumer, a crossover point exists on the cost/benefit scale beyond which it is not prudent to invest in a larger system. (In addition, available collector surface area may be exceeded.) The system designer must be able to select the optimum size based on knowledge of expected performance and system economics. A familiarity with the method of calculating optimum system size and with the tools example, FCHART, SOLOCOST, etc., must be part of the designer's repertoire.
3. *Calculate System Performance.* The system designer should be able to calculate system performance for any system type in any geographic location. A knowledge must exist of how to calculate building heat loads for sizing the system (Task 2) and how to merge this information into the predicted energy savings (contribution) which the solar system will provide. Tools such as FCHART and SOLOCOST for helping to select optimum system size with solar would be useful in calculating system performance.
4. *Identify Impact on Building Design.* With Task 1 above, the system designer will select the appropriate solar system which will best fit with the architectural design and allowable structural loads of the building.
5. *Provide Information on Operational Details.* The system designer must be able to create the necessary detailed drawings, charts, tables, etc., which size and locate solar system components in the buildings. Drawings and charts will also indicate the various modes of operational detail sufficient for the architect and mechanical engineer to understand and use. The detailed drawings should also be sufficient for the installer, electrician, supervisor and maintenance (service) persons to perform these tasks. The operational detail will include, but not be limited to, the following:
   a. Detailed drawings and descriptions of each mode of operation, including location and position of ducts, dampers, valves, etc., for the particular mode addressed;
   b. Operational ranges of system controls for each of the modes;
   c. Collector placement, altitude and azimuth angles, and attachment to building structure;
   d. Detailed drawings and description of piping and duct connections, sizing, flow balancing considerations, etc.;
   e. Component sizing and location of collectors, pumps, blowers and storage; and
   f. Detailed drawing and description of the storage component and interconnections.
6. *Describe Installation and Maintenance Details.* The information itemized in Task 5 should provide the necessary details for the system installer. In addition, the system designer should describe the routine, expected maintenance operations and scheduling of such operations.

C. **Installers.** System installers will need to have intricate knowledge of installation and construction of solar component hardware, as well as a fundamental knowledge of HVAC systems. In addition, they should have a general knowledge of system operation and design and local building codes. The installer is

the "hands-on" person capable of translating the designer's blueprints into a properly installed system. The installer should demonstrate the skills of a good craftsperson in all the work performed. As such, the installer should be able to:

1. *Install Collectors.* Be familiar with the variety of installation techniques, mounting hardware and collector interconnections. The installer must be able to mount, fasten and flash collectors as necessary to insure that collectors and support structures will withstand local climatic conditions (wind, hail, snow, etc.) and prevent roof leakage and rotting.
2. *Make System Connections to Collectors.* The installer must be totally familiar with the kinds of connections which should be made in each solar system type, including both air and liquid systems. The installer must be familiar with the various types of fittings and unions, and the soldering and sheet metal techniques associated with making such connections. In fitting collectors together and in attaching system connections, allowances for thermal expansion must be understood and incorporated.
3. *Leak Test System.* Collectors should be leak tested prior to installation for both internal leakage faults in the absorber plate and external leakage through the collector housing. The installer must also be able to flush the system (in the case of liquid systems), fill the system with appropriate fluid and pressure test the system for leaks.
4. *Locate, Construct and Install Storage.* The installer should be familiar with various types of storage systems, containers, tanks, etc., which can be employed in solar systems. The installer should be able to construct storage systems, usually in the case of rock storage/air systems. Familiarity with considerations for properly locating the tank or storage bin must be understood; i.e., allow room for interconnections, insulation, servicing, etc.
5. *Connect Pipes, Ducts to Storage.* The installer must be able to read the designer blueprints to be able to properly connect pipes and air ducts, when applicable, to the storage container. Along with Task 2 above this includes proper pitching of pipes and ductwork. This task could also involve the installation of storage sensors which will be connected to the system controller.
6. *Install Collector/Storage Heat Exchangers, Pumps, Check Valves, Filters, Isolation Valves* and other necessary hardware which interconnects and affects the collector/storage operation.
7. *Hookup System with Auxiliary (Standard Backup) Heating Unit,* including the use of filters, humidifiers, etc.

D. **Electrician.** Basically, the electrician will be used for the installation of solar controls. The electrician may not be familiar with the detailed operation of solar systems, but should be able to interpret the system information (drawing, blueprints, etc.) for successful hookup of the solar control system. On smaller systems, usually retrofits, where there is no need to connect wiring to the main service box or work directly with the 110 vac lines, then an electrician may not be necessary. In larger systems, especially larger commercial and industrial applications, an electrician will be needed. The electrician must be able to:

1. *Provide Power* to main control unit, blowers, pumps and any safety controls which the system may employ.
2. *Install Sensors*, if necessary, or insure that they are installed properly.
3. *Install Thermostat.*
4. *Connect Mechanical Device Controls to Controller.*
5. *Check Out Control Modes.* This should be done in cooperation with the person responsible for system startup.

E. **Supervise (Construction and Installation).** The supervisor of the construction and installation of the solar system will need to:

1. *Establish Schedule.* The supervisor will need to coordinate the delivery of materials with personnel schedules to insure that the installation goes smoothly and on time.
2. *Recognize Conformance with Codes.* The supervisor must insure that the solar installation does not violate any of the local building codes, ordinances, etc.
3. *Recognize Conformity of Installation with Design.* The supervisor must constantly check, as installation progresses, that the system is being installed without variance, unless approved, to the original system design.

F. **Service (Maintenance).** The service or maintenance technician needs to be extremely well-versed in all facets of solar system operations. As such, the service person must be able to:

1. *Understand the General System Operation.* Before tackling and service or maintenance operation on any system, the service person must have a working knowledge of such system.
2. *Identify the Control Modes of the System.* The service person must have a working knowledge of controller circuitry and associated wiring, understand the proper location and installation of sensors, and the temperature ranges and control points affecting the operation of various system modes.
3. *Determine if Mechanical Devices are Operational.* Experience in motor repair and operation as well as the operation of various valve types (gate, balancing, pressure-temperature relief, air vents, solenoid, etc.) is required.
4. *Identify Proper Points for Fluid Temperature Measurements.* The service person must be able to analyze whether sensors are installed properly and in proper locations for system to operate as designed.
5. *Determine if Heat Flows are "Nominal."* The service person needs sufficient knowledge of heat transfer principles to make calculations based on observed temperature measurements to determine if the actual heat flows are within the acceptable tolerances as compared to theoretical.
6. *Identify Location of Problems.* The service person must be able to coordinate systems knowledge, systems operation, and testing and measuring techniques to be able to localize the problem(s).
7. *Fix Problems.* Once the problem has been isolated, the service/maintenance person must have the ability to fix the specific problem. In some instances, the service person may have isolated the problem, but will not be able to perform the repair himself. In such cases, the service person must know whom to contact to correct the situation.
8. *Perform Periodic Maintenance Checks.* Maintenance of pumps, motors, blowers and anti-freeze checks may be required, depending on the system type. Change of filters and system flushing may be needed in certain systems. The maintenance person should be able to perform all the maintenance tasks as specified by the system designer.
9. *Perform System Startup.* On small system installations, for example swimming pool and domestic hot water applications, the system startup function will be performed by the service/maintenance person. Knowledge to perform the tasks listed above should be sufficient to be able to check out and correct problems in smaller systems. In larger, more complex systems, especially in commercial and industrial applications, the systems startup function will be performed by one well-versed in large-scale applications who will have full working knowledge of the total system operation (design function), installation, and electrical service/maintenance. Insurance that the system is operating as designed is the task of the system startup person. In the larger systems, the system startup person may be supervising a team of persons as the system is engaged. System startup in larger systems may be the responsibility of the mechanical contractor.

Chapter III has focused on six jobs/job functions. An alternate approach to classification of job functions and tasks was done in a master's thesis done by William D. Hunt of California State University at Chico, California, entitled "Solar Technicians and Mechanics: A Preliminary Occupational Task Analysis." Provided in this thesis are detailed task requirements for two jobs identified in the emerging solar heating and cooling industry. See Tables 1 and 2 for a listing of predominant solar technician and mechanic tasks as identified in this thesis.

APPENDIX D.2
Job Functions

Hunt, William D. *Solar Technicians and Mechanics, a Preliminary Occupational Analysis.* San Diego, CA: Southwest Energy Management, Inc. (7283 Engineer Road, Suite G, 92111), 1978.

Solar Technician Task Requirement

- Read blueprints and/or schematics.
- Calculate heat loss/gain.
- Size solar collector array.
- Prescribe appropriate automatic solar controls.
- Draft blueprints and/or schematics.
- Perform supervisory functions.
- Trouble-shoot, maintain and repair solar controls.
- Size or prescribe solar plumbing, to include pumps, based on "rule of thumb procedures.
- Size solar-assisted heat-pump systems.
- Size auxiliary back-up heating systems.
- Size or prescribe solar plumbing, to include pumps, based on flow rates, friction loss and other data.
- Size heat exchanger units.
- Size rock storage sub-systems.
- Sell solar apparatus.
- Size or prescribe solar-pond or solar-wall (thermal mass) systems.
- Size south-facing window systems.
- Prescribe types of movable insulation and apparatus in passive systems.
- Perform administrative functions.
- Calculate heat loss/gain in storage systems.
- Install and wire solar collector array.
- Maintain and repair solar collector array.
- Design duct work requirements.
- Size or prescribe heating ducts, vents and blowers based on "rule of thumb" procedures.
- Size or prescribe heating ducts, vents and blowers based on flow rates, friction loss and other data.
- Calculate heat loss/gain in plumbing and duct systems.
- Maintain and repair solar plumbing.

Solar Mechanic Task Requirement

- Install and wire solar control systems.
- Read blueprints and/or schematics.
- Cut and join plastic pipe/plumbing.
- Install solar collectors on existing roofs.
- Maintain and repair solar collector array.
- Maintain and repair solar plumbing.
- Maintain and repair solar blowers and fans.
- Cut and braze copper pipe/tubing.
- Install prefabricated sheet metal parts.
- Install solar collector array or solar furnace at ground level.
- Maintain and repair solar water pumps.
- Install water storage sub-systems.
- Install solar-pond or solar-wall (thermal mass) systems.
- Soft-solder electrical wires and connections.
- Install auxiliary back-up heating systems.
- Modify existing furnace to accept solar apparatus.
- Cut and/or install glass or plastic glazing in collectors.
- Install movable insulation and apparatus in passive systems.
- Modify or relocate existing plumbing and exhaust vents on roof.
- Install heating ducts and vents.
- Install solar-assisted heat pumps.
- Trouble-shoot, maintain and repair solar controls.
- Silver braze copper alloy pipe and sheets.
- Cut, bend and fabricate sheet metal parts.
- Perform supervisory functions.
- Cut, thread and install galvanized pipe/plumbing.

APPENDIX D.3

Job Standards and Needs

Karaki, S., D. Ward, and C. Winn. "Training Courses for Practitioners to Design, Install and Operate Solar Heating and Cooling Systems for Residential Buildings." Fort Collins, CO: Colorado State University, Solar Energy Applications Laboratory. Paper presented at "Sharing the Sun 76" Conference, Winnipeg, Manitoba, Canada, August 15-20, 1976.

Standards for Designers

There are several functions a designer must be able to perform with regard to solar energy systems for heating and cooling of buildings. He/she must be able to:

1. Advise clients on the different types of solar heating and cooling systems appropriate for a given building and location.
2. Explain the impact of the building design on the size of the solar system.
3. Estimate the costs of solar systems and how they are affected by building designs.
4. Recommend a type of solar system that will best suit the client's needs.
5. Design the building envelope to integrate with the solar system.
6. Perform detailed designs of the solar system.
7. Calculate system performance on a seasonal and annual basis.
8. Determine the economics of the systems as compared with conventional fuel costs with inflation factors considered.
9. Provide construction details and schedules.
10. Provide supervision of construction and installation of the total system.

Needs of the Designer

The needs of a designer, simply stated, are determined by the functions she/he must be able to perform minus what she/he knows. The knowledge of individuals regarding solar systems and the interactive effects with building designs will vary considerably among the trainees. This poses a difficult problem in identifying specific needs which the training course must fulfill for the trainee. However, at this very early stage it can be safely assumed that the trainee knows very little about the design and installation of solar systems.

The needs of the designer to fulfill his/her functions are listed below. A designer must be able to:

1. Design buildings to minimize heating and cooling loads consistent with accepted construction practices.
2. Determine the solar and ambient temperature design conditions for different geographical locations.
3. Determine the effects of collector tilt and orientation on energy collection throughout the year.
4. Make feasibility estimates based on approximate design guides for air and hydronic systems.
5. Calculate detailed heating and cooling loads.
6. Explain the principle functions of the components of a solar system and the interactive nature of the components.
7. Design the solar system to meet selected fractions of the total load.
8. Select components for an integrated solar system with auxiliary units.
9. Select compatible controls.
10. Determine system performance on a seasonal basis.
11. Determine system costs.
12. Determine the economics of the system based on performance and costs.
13. Use the automated computer design tools.
14. Design stand-alone domestic hot water units.
15. Design solar systems for retrofit installations.

Standards for Installers

The role of individuals who install heating and cooling systems vary considerably. When large buildings are involved, installers follow a set of design plans and use the components selected by architects and engineers or the building contractor. In smaller buildings, and particularly for single-family residential buildings, HVAC contractors or subcontractors are responsible for selecting the kind of system as well as installing them and guaranteeing performance. It is also expected to be that way with solar heating and cooling systems.

Thus, the installer of solar heating and cooling systems is expected to be able to perform the following functions:

1. Choose an effective solar system for a particular installation from among many alternatives.
2. Size the solar system to deliver a major fraction of the total heating and/or cooling needs.
3. Install the solar system integrated with a conventional system and put it into satisfactory operation.
4. Maintain the total system so that it does not significantly degrade in performance.

Needs of the Installer

The needs of an installer for conventional HVAC systems concern the type and size of the system. She/he needs to have the requisite skills to install the plumbing works or sheet metal ducts and dampers and to test and balance the system. For a solar system, the installer has the same needs, and his/her knowledge of solar systems integrated with conventional units is assumed to be minimal.

The installer of solar heating and cooling systems needs to have:

1. A practical understanding of how the systems work.
2. Knowledge of the basic functions of system components and relative sizing.
3. The skills to assemble plumbing and sheet metal ducts and dampers.
4. The capability to size the collector and component system to deliver a major fraction of the heat energy needs for the building.
5. The knowledge of basic energy conservation principles and how they affect the size of solar systems.
6. Knowledge about adapting solar systems to existing homes.
7. Knowledge of building codes which influence the solar system installation.
8. Some understanding of future developments in solar systems; those that may become practical in the near future and those that will require longer term development effort.

APPENDIX D.4

Tabulation of Task Inventory

Downen, Dick, C.W. Troutman, C.J. Kuhnle and R.D. Freemon. *Development and Implementation of Training Curriculum/Program in Solar Heating and Cooling at the Technician Level.* Waco, TX: Texas State Technical Institute, 1977.

The task inventory was one of the most effective evaluations of the program and the assessment occurred sufficiently early in the project to permit effective adjustments.

A definite change in pattern was inserted into the survey instrument at item number 23 where the tasks for the technician and the mechanic would overlap. Respondents reacted to the pattern approximately as anticipated by project personnel and this provided a significant assessment of the direction of the research work.

This inventory contained the covert question concerning design as an exclusive function of the engineer. The column was intentionally omitted from the survey instrument to test the reaction of the respondents to the issue. Respondents voluntarily inserted the column; consequently,project personnel included the information in the tabulation process.

Appendix F provides the mailing list of 127 firms that received the survey instrument of the task inventory. The thrust of the inventory was directed towards that segment of the industry that emphasized installation and maintenance rather than manufacturing or production. The response rate was 76% with 97 of the 127 firms providing answers to the questionnairres. The distribution of the responses by size of the firm (number of employees) is as follows:

0-11	personnel	32
11-25	personnel	26
26-50	personnel	16
50+	personnel	23

Tabulation of Task Inventory

	Technician	*Mechanic*	*N/A*	*No Response*	*Engineer*
	%	%	%	%	%
1. Evaluate existing and proposed buildings to determine technical and economic feasibility of installing a solar system.	77	8	8	1	5
2. Evaluates building construction and recommends energy conservation measures.	74	14	5	0	6
3. Recommends appropriate system (liquid or air) for a given application; i.e., recognizes the advantages and disadvantages of each.	78	9	5	3	5
4. Calculates building heating and cooling loads.	85	3	5	0	7
5. Sizes collector arrays and calculates system performance using solar radiation values and other related weather data.	82	1	7	0	10
6. Selects the appropriate solar collector from manufacturers' literature.	80	7	7	0	7
7. Designs thermal storage units for any given type of system; i.e., sensible (water, rocks, etc.) and latent (eutectic salts, wax, etc.)	80	4	10	0	7
8. Designs piping systems, including: selection of piping materials, pipe sizing, pump selection, thermal insulation, expansion tanks, etc.	73	18	5	0	5
9. Designs systems that are not damaged by freezing water or by corrosion.	73	10	9	0	8
10. Designs ductwork.	73	16	5	0	6
11. Designs solar space heating systems.	77	1	10	0	11
12. Designs solar space cooling systems.	74	1	13	1	11
13. Designs integrated solar heating and solar cooling systems.	72	3	11	1	13
14. Designs solar heating systems that are integrated with conventional cooling systems.	73	6	8	0	12
15. Designs solar domestic hot water systems which utilize liquid or air collectors.	77	8	4	1	9
16. Designs solar domestic hot water systems that are integrated with building solar space heating and/or cooling systems.	76	7	5	0	12
17. Designs solar swimming pool heating systems.	75	7	7	1	10

	Technician	*Mechanic*	*N/A*	*No Response*	*Engineer*
	%	%	%	%	%
18. Designs solar systems for agricultural applications (greenhouses, crop dryers, etc.)	72	3	7	5.5	10
19. Designs control systems for all types of solar systems.	75	5.5	7	1	11
20. Estimates installation costs of solar systems.	77	13	4	3	4
21. Uses automated design techniques (computers and programable calculators) for the design of solar systems and for making system economic analyses.	75	1	13	1	10
22. Is familiar with institutional constraints and incentives; i.e., access to sunlight, land use, and zoning and building codes: financial, insurance, etc.	70	15	7	4	4
23. Follows construction progress, and schedules the timely installation of solar equipment to avoid unnecessary delays and expense.	54	40	2	2	2
24. Installs collector arrays on roof or other supporting structures.	19	79	0	0	1
25. Fabricates collector supporting structures.	11	86	0	1	1
26. Installs glazings on newly installed collectors and replaces broken or damaged glazings on existing installations.	11	86	0	1	1
27. Installs piping systems, including all auxiliary components.	11	88	0	0	1
28. Installs ductwork.	6	93	0	0	1
29. Installs and maintains solar domestic hot water systems.	12	87	0	0	1
30. Installs and maintains solar swimming pool heating systems.	11	88	0	0	1
31. Installs and maintains agricultural solar systems.	12	80	1	5	1
32. Installs and maintains solar system controls.	25	74	0	0	1
33. Diagnoses system-operating problems.	42	56	0	1	1
34. Designs aoelean (wind) power systems, i.e., water pumping, electric power generation, etc.	60	67	12	13	
32. Installs and maintains solar system controls.	25	74	0	0	1
33. Diagnoses system-operating problems.	42	56	0	1	1
34. Designs aoelean (wind) power systems; i.e., water pumping, electric power generation, etc.	60	67	12	13	8
35. Installs and maintains aeolean power systems.	20	59	6	1	4
36. Please indicate the appropriate size of your firm by checking the appropriate box.	0-11 ☐	11-25 ☐	26-50 ☐	over 50 ☐	

APPENDIX E

Equipment Lists

E.1 Clark County Community College
E.2 Community College of Denver, Red Rocks Campus
E.3 Navarro College
E.4 Scott Community College
E.5 Texas State Technical Institute

APPENDIX E.1

Equipment List from Clark County Community College

Supplied by David Comarow

Instrumentation	*Price*
Flow meters, strip chart recorder	$ 2,500
Calculators, with Software	575
6 Computer Terminals	7,100
Hand Tools	2,700
*Simulators**	
Controller Bread Board Trainer	
2 Modular Liquid System Trainers (MLST)	38,00
2 Central Control Monitoring Packages (CCMP)	
Collector Arrays and Installation — 5 collectors	6,400
	$57,275

In addition to the above equipment, Clark County Community College paid $12,000 to the Desert Research Institute for a needs assessment study, a program assessment study and the development of three computer programs used in the training program.

* The Simulators were built by Desert Research Institute at cost.

APPENDIX E.2

Equipment List from the Community College of Denver, Red Rocks Campus
Solar Energy Installation & Maintenance Program

Instruments:	*Price*
2 Heliotrope General Strip Chart Recorders, Model SCR-10	$ 780.00
2 Heliotrope General Electronic Thermometer, Model ET10	258.00
1 Heliotrope General Thermometer, Model ET/DT3	96.00
1 Heliotrope General Thermometer, Model HH-230	83.00
Assortment of Heliotrope General Sensors	100.00
1 Texas Instrument TI-59 Programmable Calculator	270.00
1 Printer for above calculator, Model PC-100A	180.00
1 Hastings Air Meter, Model 6-11	150.00
1 Extension cable for above meter, Model CF-12-CM	14.00
1 T.I.F. Volume-Aire Air Balancer, Model VA-105	100.00
1 Rio Sigma Photovoltaic Pyranometer, Model RS1008	135.00
1 Rio Sigma Tingle Track Recorder for above, Model RS1009	280.00
2 Heliotrope General Electronic Thermometers, Model ETC/350	200.00
Heliotrope General TES-1 Sensors	100.00
1 Meter-Master Digital Multimeter, Model 461	150.00
Sub-total	$2,896.00

Equipment:	*Price*
1 Grumann Domestic Hot Water Package, Model 60FFT	1,150.00
2 Grumann double glazed collectors, Model 60F	550.00
8 Sungrabber 2' x 10' Collectors with Black Chrome (Rocky Mountain Products, Denver)	2,500.00
1 Domestic Hot Water System, Lordan Collectors, Mountain Mechanical Sales, Denver (three)	1,156.00
2 Solaron Air Collectors plus mounting hardware, Model CL 2003X, Capture Energy Products, Inc. Denver, CO	1,175.00
2 Solaron Air Collectors plus mounting hardware, Model CL 2003Y, Capture Energy Products, Inc. Denver, CO	1,175.00
1 Solar Air Handling Unit with thermostat and controls	300.00
5 Misc. Delta T's and other components	500.00
1 80 Gal. Sepco Storage tank with removable heat exchanger, Capture Energy Products, Inc. Denver, CO	504.00
1 Domestic Hot Water System, including 2 Insolarator Collectors, Model #SA120-1255, Mountain Mechanical Sales, Denver, CO	1,100.00
Sub-total	$10,110.00
Miscellaneous	
Miscellaneous such as hand & power tools; pumps; torches, welding equipment; collector glazings; copper sheets; piping and ducting materials; insulation; selective surface material; demonstration equipment, etc.	8,000.00
Grand Total	$21,006.00

APPENDIX E.3

Proposed Equipment List from Navarro College

This equipment list, which specifically references certain manufacturers and distributors, is meant to be typical of what is available, and not necessarily the equipment to be purchased.

Closed Loop Domestic Hot Water System	
1 Lennox "Solar Mate" Hot Water System — 3 Collectors (double glazed) including pump, proportional flow controller, expansion tank, storage tank with heat exchanger (82 gallon) and tempering valve	$1,760
1 Similar system except with single glazed collectors	1,650
2 Flow meters (approximately $90 each)	180
TOTAL FOR SYSTEMS	$3,590
Complete Solar Systems	
Minimum sized operational liquid and air systems.	
Air System Equipment	
Collectors — 200 square feet (Solaron — $16.50 per square foot)	$ 3,300
Insulated Air Ducting — 200 feet ($3.50 per foot)	700
Solar Air Mover, including differential thermostat, blower and motorized dampers (Solar Control Corp. including 25 percent educational discount)	1,195
Solarstat Solid State Solar System Monitor (Solar Control Corp. including 25 percent educational discount)	230
Domestic Hot Water Sub-Assembly, including air-water heat exchanger, circulating pump, and storage tank	330
Energy Storage System, rockbed, 200 cubic feet, 5' x 5' x 8' high. Constructed on-site. Includes: plywood and lumber, insulation, rock.	500
Water System Equipment	
Collectors — 200 Square feet (Numerous manufacturers, $16.50/sq.ft.)	$ 3,300
Insulated Piping — 200 feet @ $2.00 per foot	400
Circulating Pumps, 2 (Grundfos Pump UPS20-42-F — $75.00)	150
Storage Tank, 600 gallon, low pressure	660
Solenoid Valves (Skinner 4 @ $45.00 each)	180
Differential Controller (Hawthorne Variflow H-1510)	70
Liquid-Liquid Heat Exchanger, 2 (one for collector loop, one for providing heat load to system. $440.00 each)	880
Liquid-Air Heat Exchanger with Blower	440
Anti-freeze, 10 gallons @ $4.00 per gallon	40
SUBTOTAL	$12,375
Solar Meterological Data Instrumentation	
Solar Tracker, model ST-1	$ 820
Eppley Normal Incidence Pyrheliometer, with clear glass, model 650	980
Eppley Precision Spectral Pyranometer, with clear glass, model 646	1,090
Dual Channel Printout System, with synchronous tempotec timer, model 618-3DCP	2,250
Panel Digital Voltmeter	200
Recording thermograph, model 151-1, Science Associates, Inc.	270
Princeton Wind Set #414, Science Associates, Inc.	220
SUBTOTAL	$5,830
Solar Collector	
Used for gaining working experience with different types of collectors.	
Forty square feet each of three different liquid collectors @ $15.00 per square foot	$1,800
Modular Collector Kits (New Jersey Aluminum, $660.00 each)	1,320
Changeable Absorber Plates for Modular Collectors, copper roll bond, 2 (Kalwall Corp., $88.00 each)	176
Aluminum Roll Bond, 2 (Kalwall Corp., $55.00 each)	110
Flat Aluminum for Air Systems, 2 (Kalwall Corp., $30.00 each)	60
Circulating Pumps, 2 (Kalwall Corp., Teel pump — $55.00)	110
Air Blower, 2 (Kalwall Corp., Dayton K4C013 — $28.00)	56
Miscellaneous Materials, including sealant, tubing, ducting, insulation, etc.	250
Flowmeters, 2 (Wallace & Tiernan, model 5510A0-1-2-06 — $90.00)	180
Various Glazing Materials, including glass and fiberglass	250
Three Focusing Tracking Collector Units, with tracking mechanisms (Northrup, Inc.)	1,100
Six Parabolic Non-tracking Focusing Units (White Line Corp., $110 per unit)	660
Mounting Materials for All Collectors	850
SUBTOTAL	$6,922
Thermal Storage	
Liquid Storage System, including steel and concrete drums, supports and insulation	$ 450
Air Storage System, including plywood, lumber, insulation, rocks, etc.	450
Latent Heat Storage System, including plywood, insulation, heat storage trays, and fused salts	900
SUBTOTAL	$1,800

Instrumentation Support Equipment Special to Solar Technology

Hot Wire Anemometer (Science Associates, Inc., #447(1)-1)	$ 450
Digital Thermometer with External Thermistor Probe, 5 (Electrometics, $140 each)	700
Thermistor Sensors, 30 (Electrometics, $12 each)	360
Thermistor Switch Box (Electrometics)	25
Thermistor Hook-up Wire, 3,000 feet (Radio Shack, $0.10 per foot)	300
Flowmeters, 3 (Wallace & Tiernan, model 5510A0-1-2-06, $93)	279
SUBTOTAL	$2,114

Solar System Simulators

Simulators are extremely useful for teaching principles before the student experiments on the real equipment. This type of simulator is completely interactive, permitting the teacher to familiarize the student with the effect of varying numerous solar parameters. Twenty-four major system malfunctions can be inserted by the teacher to introduce the student to trouble-shooting.

Solar System Simulators (Omnidata, Inc., model 327)	$6,385
Printer Drawer Interface (Omnidata PDI-1)	252
Student Tracking Printer (Omnidata STP)	875
SUBTOTAL	$7,512

Calculators

Many of the sizing and design calculations are being carried out on small, programmable calculators. There are several companies making available prewritten program cards for solar sizing and design calculations. Calculators of this type are not standard equipment at most colleges.

Programmable Calculator, 2 (Texas Instruments, Model 59 — $253.00)	$ 506
Printer for Calculator, 2 (Texas Instruments, model PC-100A — $176.00)	352
Programmable Calculator with printer, 2 Hewlett-Packard, Model 97 — $710.00)	1,420
SUBTOTAL	$2,278
Shipping estimate for above items:	2,500
TOTAL LABORATORY COSTS	$44,921

In addition, one could spend another $6,000 on solar refrigeration equipment and $2,000 on photovoltaic equipment. As well, there will be construction costs incurred for installation of outdoor demonstrations. Navarro College has estimated such costs to be around $8,500.

APPENDIX E.4

Equipment List from Scott Community College

ITEM	QTY.	DISTRIBUTOR	COST Unit	COST Total
Alnor Velometer	1	Dennis Co.		453.20
Solar System Trainer AP-3	1	Lennox		2,500.00
ST-17 Solar Heat Service Trainer	1	Lennox		1,500.00
GB 5 Solar Schematic Trainer	1	Lennox		700.00
Solar Panels Complete	1	Solaron		6,347.81
Solar Aire Demo System w/collectors Air Control Unit. Storage Package (1500 trays). Installation manual	10	Illowa Solar	662.00	6,620.00
FVU Flo Vu Water Table	1	Lennox		795.00
RT5 Solar Cycle Trainer	1	Lennox		700.00
EB3 Heat-Cool Schematic Elec.	1	Lennox		495.00
EB2 Heat-Cool Schematic Oil	1	Lennox		495.00
RT-3 Heat Pump Cycle Tr.	1	Lennox		695.00
EB-4 Heat Pump Schematic Tr.	1	Lennox		750.00
ST-1A Potential Relay Tr.	1	Lennox		360.00
ST-2 Basic Electricity Tr.	3	Lennox	350.00	1,050.00
ST-4 Gas Heat Service Trainer	1	Lennox		1,195.00
ST-7 Direct Spark Ignition Tr.	1	Lennox		795.00
ST-9 Heat Pump Service Trainer	1	Lennox		1,295.00
ST-17 Solar Heat Service Trainer	1	Lennox		1,500.00
BT-1 Bi Metal Trainer	1	Lennox		495.00
GT-1 Gas Fundamentals Trainer	1	Lennox		440.00
OT-1 Oil Fundamentals Trainer	1	Lennox		415.00
OT-2 Cad Cell Trainer	3	Lennox	150.00	450.00
OT-3 Oil Burner Trainer	1	Lennox		580.00
OT-4 Oil Pump Trainer	1	Lennox		350.00
MIP-7 Flue and Chimney Trainer	3	Lennox	85.00	255.00
MIP-8 Plastic House Trainer	3	Lennox	165.00	495
AP-2 Air Distribution System Tr.	2	Lennox	995.00	1,990.00
AP-5 Hydronic Principles Trainer	1	Lennox		795.00
SHW-2 Domestic Water Heater — solar	1	Lennox		1,450.00
LE-8 Solar Test Equipment	1	Lennox		1,880.00
LE-4 Basic Test Equipment	1	Lennox		1,195.00
322 Electric Home Alc.	1	Omnidata Inc.		3,615.00
STP Student Tracking Printer	2	Omnidata Inc.	705.00	1,410.00
326 Heat Pump Technology	1	Omnidata Inc.		4,198.00
327 Solar Energy Simulator	1	Omnidata Inc.		5,833.00
			Total	$54,092.01

Current prices may differ from the figures listed above.

APPENDIX E.5

Equipment List from Texas State Technical Institute

The following is considered minimum for a program with an enrollment of approximately 30 students. All costs are estimated and relative to current market values.

Building (Approximate Areas)		*Estimated Costs*
1. Classroom	800 SF	
2. Audio Tutorial Lab	1,000 SF	
3. Static Display Area	1,200 SF	
4. Office, Library and Instructional Material Storage	800 SF	
5. Operating Equipment Lab	2,200 SF	
	6,000 SF	
6,000 SF at $40.00/SF (new construction) =		$240,000.00

Audio-Visual Training Equipment		
1. Study Carrels, 30 @ 75.00	$2,250.00	
2. Tape Players, 30 @ 50.00	1,500.00	
3. 35mm Slide Projectors, 15 @ 200.00	3,000.00	
4. 15mm Movie Projector, 1 ea.	800.00	
5. Tape Player-Recorders, 2 @ 100.00	200.00	
		$ 7,750.00

Operating Equipment		
1. Commercially Produced Trainers	$10,000.00	
2. Operating Domestic Hot Water Heating System	2,000.00	
3. Operating Air Type Space Heating and Domestic Hot Water System	15,000.00	
4. Operating Liquid Type Space Heating and Cooling System with Domestic Hot Water	30,000.00	
5. Swimming Pool Heating System	2,000.00	
		$ 59,000.00

Notes: 1) Items 2, 3, & 4 above are intended to actually contribute to building energy requirements.

2) It would be desirable to have the above swimming pool heating system in actual use if campus has a swimming pool.

Static Display Equipment		*Estimated Costs*
This will consist of all types of solar related products: collectors, pumps, pipe displays, controls, display boards, etc.		$ 6,700.00

Tools & Instruments		
1. Hand Tools	$2,000.00	
2. Oxy-Acy Torch	200.00	
3. Vacuum Pump	350.00	
4. Volt Ohm Meters, 10 @ 60.00	600.00	
5. Amp meters, 10 @ 60.00	600.00	
6. Pyranometer w/Indicator	1,200.00	
7. Liquid Flow Meter	200.00	
8. Air Flow Instrument	350.00	
9. Thermometers, 50 @ 10.00	500.00	
10. Pressure Guages, 20 @ 15.00	300.00	
11. Hydrometer	50.00	
12. Vacuum Guage	200.00	
		$ 6,550.00
TOTAL COST ESTIMATED		$320,000.00

Faculty

1. Two full-time instructors
2. One full-time paraprofessional

Note: Above costs do not include expendable materials or costs of instructional material software.

APPENDIX F

Related Journals/Periodicals/News Publications

ADVANCED SOLAR TECHNOLOGY
1609 W. Windrose
Phoenix, AZ 85029
Subscription Rate: $60.00.
Issue Rate: Monthly.

CURRENT ENERGY & ECOLOGY
Curriculum Innovations, Inc.
501 Lake Forest Avenue
Highwood, IL 60040
Subscription Rate: $3.75 (student).
Issue Rate: Monthly, Sept. to May.

NEW ENGLAND SOLAR ENERGY NEWSLETTER
P.O. Box 121
Townshend, VT 05353
Subscription Rate: $15.00.
Issue Rate: 10 issues/yr..

SOLAR AGE
Solar Vision, Inc.
Route 515, Box 288
Vernon, NJ 07462
Subscription Rate: $20.00.
Issue Rate: Monthly.

SOLAR ENERGY
The Subscription Fulfillment Manager
Headington Hill Hall
Oxford OSC OBW, England
Subscription Rate: $30.00.
Issue Rate: Bi-monthly.

SOLAR ENERGY DIGEST
P.O. Box 17776
San Diego, CA 92117
Subscription Rate: $28.50.
Issue Rate: Monthly.

SOLAR ENERGY INTELLIGENCE REPORT
Business Publishers, Inc.
P.O. Box 1067, Blair Station
Silver Springs, MD 20910
Subscription Rate: $67.00.
Issue Rate: Weekly.

SOLAR ENERGY UPDATE
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Subscription Rate: $27.50.
Issue Rate: Monthly.

SOLAR ENGINEERING
Anna Fay Friedlander, Editor
8435 N. Stemmons Freeway
Suite 880
Dallas, TX 75247
Subscription Rate: $15.00.
Issue Rate: Monthly.

SOLAR HEATING AND COOLING
Gordon Publications
P.O. Box 2126-R
Morristown, NJ 07960
Subscription Rate: $6.00.
Issue Rate: Bi-monthly.

SOLAR NEWS AND VIEWS
ISES American Section
P.O. Box 1416
U.S. Highway 190 West
Killeen, TX 76541
Subscription Rate: $10.00.
Issue Rate: Quarterly.